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ADVERTISING RATES GIVEN ON APPLICATION.

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WASHINGTON MEETING OF THE AMERICAN ELEC- TROCHEMICAL SOCIETY.

After winning its spurs by two years of progress unparal-
leled in the history of any other of our national engineering
societies, the increasingly vigorous and active American Elec-
trochemical Society is about to make its debut at our National
Capital. To the maiden record of four highly successful gen-
eral meetings is about to be added another, and probably the
most interesting meeting so far held. In addition to the
abundance of electrochemical communications offered for read-
ing—papers which by their variety and scope will interest the
whole fraternity—the programme bristles with visits to labora-
tories and museums, excursions in and around “our most
beautiful American city,” and, *pour comble de la bonté*, a re-
ception of members by the Chief Magistrate of our country.
With each member of the American Electrochemical Society,
when he reads the programme of the meeting, the question will
no longer be “Do I care to attend,” but “Can I possibly attend.”
We predict the most numerously attended and most enjoyable
assembly yet held by this unique society.

THE ANATOMY OF THE ATOM.

The late Prof. Rowland, of Johns Hopkins, often used to
ask: “Who will be the Kepler of the molecule?” To strive
at such honors, was a natural object of ambition on the basis
of the old theories of chemistry. For a molecule has generally
been considered as a system of atoms which are kept together
by mysterious forces, in a similar way as the system of the
sun and its planets is held together as a self-contained unit.
The development of the electronic hypothesis has brought for-
ward in recent years another and still more fundamental
problem of molecular physics. We have witnessed the destruc-
tion of the popular faith in the atom’s indivisibility which defi-
nition and tradition had formerly assigned to it. The atom is
now claimed to be itself a complicated system, and its funda-
mental components are the electrons. But the objection, occa-
sionally raised, that the electron theory tends to degenerate into
metaphysics, was troublesome. To overcome such criticisms it
was necessary to form a mathematically exact model—in Max-
well’s sense—of the structure of the atom. J. J. Thomson,
Maxwell’s successor as the Cavendish professor of experi-
mental physics at Cambridge and himself one of the very
founders and exponents of the electron theory, has performed
this task in a most remarkable and most ingenious paper pub-
lished in the March issue of the Philosophical Magazine and
abstracted at length in the Synopsis of our present issue.

Thomson starts from a purely mathematical problem; that
of the motion of a ring of a given number of negatively electri-

fied particles (or corpuscles, as he calls the electrons) placed inside a uniformly electrified sphere. His first equations are simple enough. He assumes the corpuscles to be arranged at equal angular intervals round the circumference of a circle inside the sphere; the uniform charge of positive electricity within the sphere exerts a radial attraction on each corpuscle, while a repulsion is exerted on it by the other corpuscles. The condition of equilibrium is that this attraction and repulsion are equal. If the ring of corpuscles, instead of being at rest, is rotating with a given angular velocity, the equation for the condition of steady motion is derived from the condition at rest by simple principles of analytical mechanics. Then Thomson proceeds to find the forces acting on a corpuscle when the corpuscles are slightly displaced from their positions of equilibrium, and shows how to determine the frequencies of oscillations. His general formulas become unwieldy like a symphony of Richard Strauss. Yet the tendency which he follows, is clear in all his mathematics; and then, modulating his leading theme, he applies his general equations to calculate the frequencies for systems containing various numbers of corpuscles—two, three, four, five. His mathematics becomes again more and more complicated. For six corpuscles he finds that their arrangement in one ring is necessarily unstable. But peace reigns again, when he puts one more corpuscle into the center; and gradually increasing the number of corpuscles, he finds that if there is to be equilibrium, the corpuscles must arrange themselves in rings; one inside another, the number of corpuscles within a ring gradually decreasing towards the center.

It is, of course, clear that this ring structure of the atom is not exactly the model Thomson is after. What he wants to get at is rather a system of shells instead of rings within the sphere. With the same frankness which distinguished Maxwell in his papers, Thomson now states that on account of the great analytical and geometrical difficulties of the problem of the distribution of the corpuscles in shells instead of rings, he has not as yet succeeded in getting a general mathematical solution for the former case. But nobody who appreciates Thomson's paper at all, will find that its intrinsic value is thereby impaired. It is evident that the same kind of properties will be associated with the shells as with the rings; and since in the latter case Thomson is able to study the problem quantitatively, he is right to do so. Considered simply as a work of mathematical art, Thomson's paper is equal to anything that Maxwell or Boltzmann have produced on similar lines—in the directness by which the problem is attacked, in the beauty and ingenuity of the methods by which it is conquered, and in the inherent complications of the mathematical apparatus involved.

The same objection which has sometimes been raised against Maxwell's and Boltzmann's work in the mechanical theory of heat, may, however, be also made against Thomson's model of the structure of the atom—namely, that too much ingenuity is spent for the purpose of arriving at facts which are well known. It is true that Thomson brings out no new chemical facts. His paper is like Sophocles' *Oedipus*—one knows all the results in advance; and, as in that overwhelming Greek drama, so in Thomson's paper, the whole interest centers in the

way in which the results which will and must come, are reached. Thomson shows that if an atom consists of a number of negatively charged corpuscles moving about in a sphere of uniform positive electrification, then the corpuscles must be assumed to form a series of concentric shells, and then Thomson goes on to show that the properties conferred on the atom by this shell structure are analogous in many respects to those possessed by the chemical elements, and that in particular the properties of the atom will depend upon its atomic weight (which is proportional to the number of corpuscles in it) in a way very analogous to that expressed by the periodic law. He shows why the elements arrange themselves into the groups of the periodic system. He develops the main laws of the line spectra of the series of elements. He explains the variation of valence and the change from the electropositive to the electronegative character of the elements, when one passes from the left to the right in a horizontal row of Mendeléef's table. He finally gives a new conception of the radioactive atom. All these results follow in such a simple and natural way with absolute consequence from his shell structure of the atom, that the whole scheme is one of the most wonderful achievements ever attained in theoretical physics. For this reason we need not apologize for the unusual length of the extract which we give in our Synopsis from this part of Thomson's paper.

According to Kirchhoff, the object of theoretical physics is to describe the facts in as complete and as brief a manner as possible. A statement of "laws of Nature"—either with or without the aid of mathematics or of mechanical models or analogies—is nothing but a brief description of a group of facts. Of course, such a law can become wider than the group of facts which it was originally intended to describe, and then we can use the law to derive from it new results and to predict facts which have not yet been ascertained by experiment. But only by afterwards establishing experimentally these theoretical results to be facts, we prove the law to be correct. Thomson's model of the structure of the atom is the first scheme ever devised for a consistent description of the facts of the periodic system of the chemical elements. It is a surprisingly complete and brief description of these facts, if we once accept the shell structure of the atom. But the original conception of the atom as a series of concentric shells of corpuscles within a sphere of uniform positive electrification seems highly artificial, not so much on account of the shells of corpuscles which are a comparatively simple conception, but on account of the sphere of uniform positive electrification, which, while mathematically sharply defined, will appear somewhat mysterious to the average man. We should not forget, however, that it was from such models, which were apparently very artificial, that Maxwell started in the evolution of his electromagnetic theory.

ELECTROLYTIC PRECIPITATION OF GOLD.

In this issue we publish a very interesting paper by Mr. Hamilton on the modifications which the Siemens & Halske process for the electrolytic precipitation of gold, as originally operated in South Africa, has afterwards undergone in this country and in Mexico. Nothing that is essential has been changed in the chemistry of the process, the modifications relating

rather to changes in details. But, as is often the case in industrial chemistry and metallurgy, such apparently small changes may be of the very greatest practical importance, and may often decide the commercial future of a process. The first modification of the original Siemens & Halske process consists in the substitution of a lead peroxide anode for the iron anode. The result is that the anode is thus rendered practically indestructible, that no such compounds are formed as Prussian blue with iron anodes, and that the anode is no longer covered with canvas or the like; and what is most important, the anode, being indestructible, no longer limits the value of the current density which can be used.

The second modification relates to the cathode. The gold is no longer plated upon the cathode but is deposited in form of slime, which drops to the bottom. The method of cleaning out is simple. The cathode plates, which are now made from tin, are continually in the tanks and a good joint between the cathodes and outside conductors is assured. This evidently renders the whole method of handling much easier. The important question is now what is the best current density to be used. The author shows that it depends on three factors—the percentage of gold in solution, the rate of flow of the solution, and the area of the electrodes. He gives some very interesting data on these points, and also gives an account of some experiments which he has made on certain other questions which are not only of practical importance, but of great theoretical interest. We intend to refer to the same again in a later issue.

THE POWER PROBLEM.

In order to carry on any manufacturing process with a profit, it is necessary that the cost of raw materials plus the cost of operation plus the cost of shipping of the raw materials to the place of operation, and of the manufactured product to the place of consumption is smaller than the price which one finally gets. In electrochemical and electrometallurgical industries the cost of power is one of the main items and often the most important item of the cost of operation. But cheap power is not the only condition of the financial success of electrochemical industries; the source of cheap power must be at the right place to avoid large expenses for freight. No general rules can be laid down concerning the place where the cheap power should be available in order to make the cost of shipping a minimum. For instance, for manufacturing nitrates from the nitrogen of the air there would be no expenses for the raw material nor for its shipment; hence a source of cheap power should be chosen near the place where the nitrates are to be sold. On the other hand, in the reduction of metals from their ores, the freight expenses would be smallest, if the process is carried out near the mine, provided cheap power is there available. In general, we may say that the prospects for electrochemical and electrometallurgical industries are most promising wherever there are cheap raw materials and cheap power, provided the product is valuable enough to also pay for the shipment of the products to the market place. In this respect the United States is greatly favored by Nature, as is indicated by some statistical data, given in 1899 in a German Electrochemical Society paper of Prof. W. Borchers.

According to Borchers, the power developed for electrochemical and electrometallurgical industries in this country at that date were 86,350 hp., or 20 per cent of the total 421,220 hp. of all the electrochemical plants of the world. On the other hand, the value of the products which could be made per year by utilizing the 86,350 hp. to their full extent, was \$97,500,000, or 67 per cent of the corresponding value for the whole world, which is \$146,500,000. While these figures, considered as absolute values, are now somewhat stale, they emphasize extremely well the fact which we wish to bring out. It is the discrepancy between 20 per cent—the proportion of power developed for electrochemical purposes in the United States to the corresponding value in the world—and 67 per cent—the analogous proportion for the value of the yearly products. This discrepancy is, of course, explained by the fact that this country has an abundance of valuable ores from which highly valuable metals may be obtained.

With regard to the availability of raw materials for the manufacture of valuable products, the United States is thus immensely favored by Nature in comparison with other countries, and thus the principal condition for the successful development of electrochemical and electrometallurgical industries is fulfilled in this country to a high degree. Under these circumstances it is the power problem which is now attracting special attention. Steam power has often been considered to be too expensive for electrochemical purposes; but that steam is not entirely out of the race is shown, to mention only one instance, by a large electrolytic alkali plant in Michigan, where coal is cheap. For the central station engineer, electrochemical plants should be very attractive as customers, since there is probably no electric plant which has such a uniform load during day and night, and during the whole year, as most electrochemical and electrometallurgical works. The introduction of the steam turbine on a commercial scale also seems to improve the prospects for steam power. Water power developments have been most intimately connected with certain electrochemical industries in the past, and there is no reason why there should be a change in the future. Niagara Falls is not only the largest water-power plant, but also the most prominent center of electrochemical industries in the world. In this country it is most fortunate that several of the largest water-powers are just where they are wanted, that is, not at out-of-the-way spots, but at places which are conveniently situated for shipping. Most recently, gas engines are pushing vigorously to the front, and some data given by Dr. Nagel in an article in this issue will prove interesting reading. It is especially the utilization of the waste gases from blast furnaces which should have a great future. Their utilization for operating gas engines, coupled to electric generators for electric lighting and for general power purposes, is sure to come, and the operation of electric furnaces for making special steels in conjunction with our present blast furnaces seems a logical development. Whatever is best to use, whether water or gas or steam power, depends, of course, on the conditions of each special case. Such most conveniently located water powers, like Niagara, will, of course, continue to attract in future electrochemical industries. On the other hand, extended coal centers, like Pennsylvania, will be very attractive for gas-power developments; and in our large blast furnace plants the furnace gases will no longer be wasted.

WASHINGTON MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The fifth general meeting of the American Electrochemical Society will be held in Washington, D. C., on Thursday, Friday and Saturday, April 7th, 8th and 9th. This will be at the same time the third annual meeting and the election of new officers will be announced.

The meeting will be held at the Columbian University, corner Fifteenth and H Streets, N. W. In the mornings of the three days, meetings will be held devoted to the reading and discussion of papers, and to the transaction of the business of the Society, Thursday and Friday afternoons will be devoted to visits to scientific laboratories, government institutions and various points of interest in and about Washington; on Thursday evening, the presidential address will be delivered and will be followed by a complimentary smoker, while Friday evening a subscription banquet will be held at the Shoreham, corner Fifteenth and H Streets, N. W., opposite the Columbian University. The Shoreham will also be the hotel headquarters during the convention.

The chairman of the local committee is Col. Samuel Reber, the Secretary, Mr. C. P. Townsend. The finance committee consists of Col. Samuel Reber as chairman and Messrs. C. P. Townsend, T. A. Witherspoon, H. H. Seabrook, W. D. Young; the entertainment committee of Dr. N. M. Hopkins as chairman, and Dr. E. A. Byrnes and Mr. W. O. Snelling; the executive committee, Dr. H. W. Wiley as chairman, and Dr. M. G. Lloyd, Mr. A. B. Marvin, Mr. Henry J. Lucke and Dr. Edward Keller.

The following papers will be read and discussed at the meeting of Thursday, April 7:

"Standard Cells," Dr. F. A. Wolff; "The Preparation of Materials for Clark and Weston Standard Cells," Dr. H. S. Carhart and Dr. G. A. Hulett; "Single Potentials of the Halogen Elements," W. R. Mott; "The Composition and Resolution of Voltages," Dr. J. W. Richards; "Molecular Conductivity," C. J. Reed; "Remarks on Prof. Richards' Theory of Heat of Neutralization," Gustaf M. Westman; "The Energy of Ions," Dr. L. A. Parsons; "The Aluminium Electrolytic Condenser," C. I. Zimmerman.

For the Friday meeting the following papers are announced: "Electrolytic Iron," Prof. C. F. Burgess and Carl Hambuechen; "The Economic Balance in Electrolytic Copper Refining," Lawrence Addicks; "A New Electrolytic Separation of Gold and Silver," Herman Poole; "Observations on the Preparation of Electrolytic White Lead," C. F. Carrier, Jr.; "The Relation Between the Cost of Salt and the Cost of Power at a Given Locality, and the Resulting Cost of Electrical Bleaching Liquor Produced," Dr. W. H. Walker; "A Relative Decimal Index for Electrochemical Interests," Adolph L. Voegelé; "Notes on the Industrial Electrolysis of Water," W. S. Landis.

At the Saturday meeting the following papers will be presented:

"A Contribution to the Study of the Electric Arc," Dr. William S. Weedon; "Electric Smelting Experiments for the Manufacture of Ferro-Nickel from Pyrrhotite," Ernst A. Sjöstedt; "Some Experiences in Copper Precipitation," Hermann Poole; "The Relation of the Alternating Current to Osmotic Pressure," W. H. Davis; "Some Phenomena Observed in Connection with the Use of a Copper Voltmeter," Isaac Adams and Barry MacNutt.

GERMAN POTASH SYNDICATE.

A recent consular report (dated January 21) from United States Consul-General Mason, of Berlin, Germany, reads as follows:

During the past three days the representatives of the associated potash mineral interests have been in session at Berlin trying—but thus far without success—to agree upon a plan by which their hitherto iron-girt and inflexible working and

sale syndicate can be prolonged beyond the close of the present year. As an illustration of the ethics of syndicate management under natural conditions, which constitute a practical monopoly of an important group of products, the potash trust of Germany, known as the "Verkaufs-Syndikat der Kaliwerke," possesses a unique interest.

As is well known, Germany possesses the only known workable deposit of potash minerals in the world.

Under the management of a syndicate, or combine, the prices of all potash minerals and refined salts were fixed for the home market and for export, and the rate of production so regulated that the supply should never overload and depress the market. So matters went on peaceably for many years; a large and constant demand for potash fertilizers was developed in the United States, which took regularly something more than half of the entire exported supply. These potash fertilizers are used largely in the United States in combination with the mineral phosphates of the Carolinas and Florida, the production and sale of which likewise fell, in the course of years, largely into the hands of a powerful and ably managed company, or syndicate, which has its headquarters in the capital of one of the Southern States. This company finally grew weary of the limited supply of potash materials and the high prices charged for them by the German syndicate, and during the spring of 1902 sent some of its leading managers, with a mining engineer, to Germany, where they undertook openly and above board to secure by purchase some of the more important independent potash mines outside the syndicate, from which to obtain, as they hoped, a direct and permanent supply under their own control.

The sensation that was caused by this American movement to break into the sacred precincts of the German potash monopoly will long be remembered. They failed, for the time being, to secure any important mining property, although they succeeded later in purchasing one or two producing mines, which they are now operating for the production of refined potash salts. But the two notable results of the American negotiations at that time were that the Southern Fertilizer Company secured a favorable contract with the Stassfurt Syndicate for the delivery of an increased annual supply of potash minerals and salts for export to the United States, and, secondly, the syndicate itself was alarmed and admitted as members a number of outside mining companies, which it had previously refused to accept. This raised the whole number of firms and companies included in the syndicate to 27, and, of course, greatly increased its productive capacity. Many of the new members had their mines fully developed and equipped, and were eager to begin operations on a large scale. The result was that the enlarged syndicate started out with great activity and high hopes during the spring of 1902, but soon found its rate of production so far beyond the capacity of the market at syndicate prices that by the middle of July there was a glut of unsold material, which necessitated an abrupt contraction of the general output.

The proposition is to formulate and adopt a new and broader contract, which shall continue five years from the 1st of January, 1905. Whether this can best be done under a cartel similar to the agreement now in force or as a stock company with limited liability is a point upon which some of the members sharply disagree.

There is, of course, a definite limit to the distance to which minerals worth only \$2.54 to \$3.45 per ton can be profitably transported, and it is probable that the future development of the potash industry will be largely in the direction of a greatly increased production of concentrated potash salts and the elimination thereby of the large percentage of dross or waste that now encumbers traffic in the crude minerals.

The erection of the Union Engineering Building is now assured. Mr. Andrew Carnegie has donated \$1,500,000 for the building, while the four societies will acquire the land.

THE CORROSION OF ALUMINIUM AND ITS PREVENTION.

By WILLIAM ROY MOTT.

A study of aluminium and its properties is of considerable importance. The commercial value of aluminium follows, as is well known, mainly from its workability, strength, lightness, lustre, electrical conductivity, permanence and cheapness. Many irregular data are extant upon its permanence and corrosion. The lightness of aluminium greatly commends its use for utensils in military camps; extensive tests have been made by the French military experts in this direction. Many articles of aluminium in domestic use are subjected to the corrosive action of the sodium chloride in the preparation of foods and in contact with the perspiration of the human hand. Many striking cases of corrosion of this kind are met with. Burgess and Hambuechen have given an instance of this kind of corrosion, in their paper upon aluminium, published in the *ELECTROCHEMICAL INDUSTRY*, January, 1903. In this paper the formation of a film over aluminium was carefully discussed from several viewpoints. As was pointed out, a film forms over an aluminium anode in certain solutions, such as sodium acid phosphate. This film has been found by the author to greatly decrease the rate of corrosion of aluminium. It is experiments upon this special protective action of this film that the author proposes to detail here.

This film is many times thicker and chemically different from the ordinary film that forms upon aluminium in air.

Aluminium on which this film has been formed shows decidedly less chemical action. Aluminium plates formed at 125 volts were tested as to rate of action (table I.) with normal hydrochloric acid (plate I.) potassium hydroxide and normal sulphuric acid (plate II.). The aluminium plates, of nearly the same size, were acted upon by the same reagents under like conditions. The action of hydrochloric acid upon the untarnished plate is one hundred times faster than upon the plate on which a film is formed; but after one hour the action

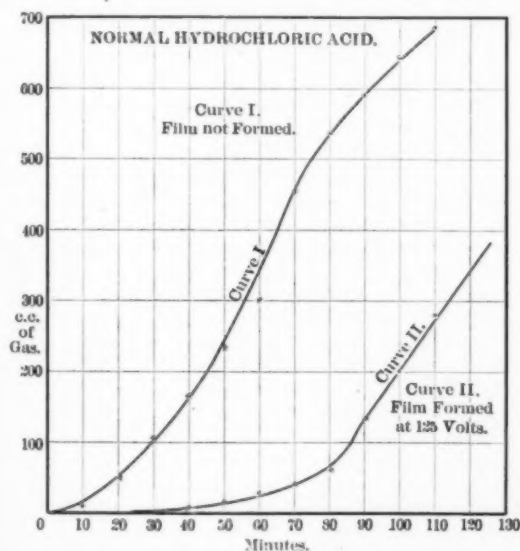


PLATE I.—ACTION OF HYDROCHLORIC ACID.

on the unformed plate is only six times faster than on the formed plate. After two hours the rate of action is practically the same on both.

Normal potassium hydroxide acted with nearly equal rate on both plates, and the corrosion was nearly uniform. This was to be expected, since potassium hydroxide readily dissolves the oxide and hydroxide. The corrosion of the formed plate by hydrochloric acid is worthy of note. It starts in spots, seems to creep under the film, and causes it to peel

off in plates. At these exposed places the action is vigorous. On taking the plates out, portions protected by the film remained uneaten.

The action with sulphuric acid was one thousand times slower than with hydrochloric acid or potassium hydroxide. Here the metal protected by the film gave off less gas than the other, especially within the first ten hours. The reason for the slow action of the sulphuric acid, is no doubt due to the fact that it is one of the agents which can be used to form the film. Quantitative measurements on disodium hydrogen phosphate showed that this acted at nearly the same rate as the sulphuric acid.

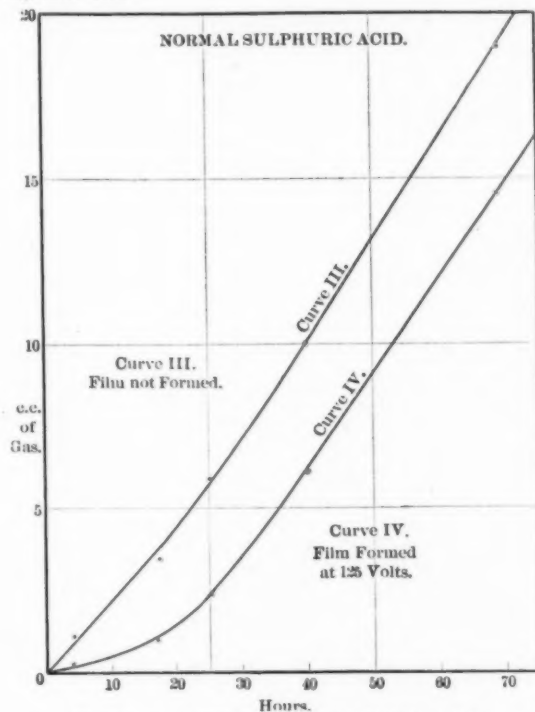


PLATE II.—ACTION OF SULPHURIC ACID.

TABLE I.—RATE OF CHEMICAL ACTION WITH THE FORMED AND NOT FORMED ALUMINIUM PLATES.¹

NORMAL HYDROCHLORIC ACID. ²			NORMAL SODIUM HYDROXIDE. ⁴			NORMAL SULPHURIC ACID. ⁵		
Time in Minutes.	Number 1. ³	Number 2. ³	Time in Minutes.	Number 3. ³	Number 4. ³	Time in Hours.	Number 5. ³	Number 6. ³
10	9.0	.00	10	10	8	4	1.0	0.1
20	50	0.10	20	10	..	17	3.4	1.0
30	110	2.0	40	22	24	25	5.8	2.4
40	170	5.0	60	26	27	40	10.0	6.0
50	230	9.2	240	40	41	69	19.0	14.5
60	300	18						
70	450	32						
80	540	55						
90	595	135						
100	650	200						
110	690	280						

¹Area of plates was, approximately, ten square centimeters.

²1, 3 and 5 not touched and film not formed.

³2, 4 and 6 formed at 125 volts in disodium hydrogen phosphate solution at room temperature.

⁴These readings of cubic centimeters represent only the quantity of gas given off in ten minutes.

⁵These readings represent the total gas in cubic centimeters given off in that time.

Aluminium strips (area 10 square centimeters) were formed using direct current at pressures, as indicated in table II. The strips, formed with alternating current, were sub-

jected to the pressure indicated in table III. for five minutes each. The maximum pressure of an alternating current is, of course, considerably greater than the effective pressure which the voltmeter measured.

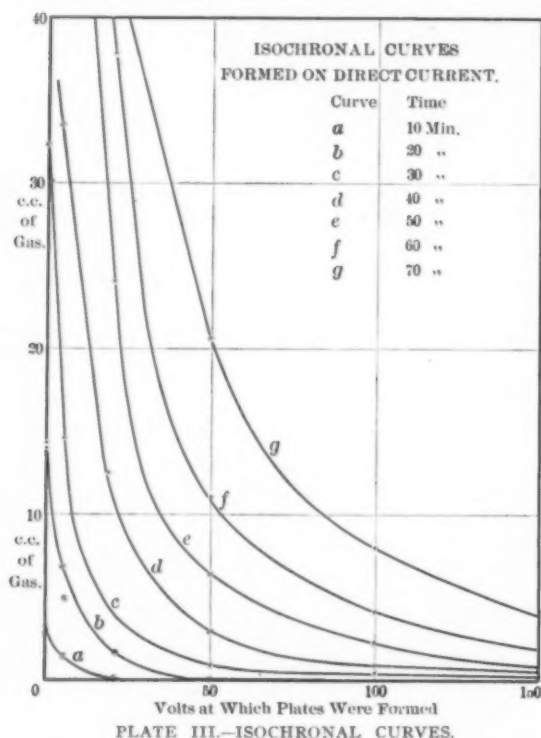


TABLE II.—ALUMINIUM PLATES FORMED WITH DIRECT-CURRENT.¹

Volts. Min.	Not Touched Gas. Cu. Cen.	Washed ² Gas. Cu. Cen.	1 Volt. Gas. Cu. Cen.	5 Volts. Gas. Cu. Cen.	10 Volts. Gas. Cu. Cen.	30 Volts. Gas. Cu. Cen.	50 Volts. Gas. Cu. Cen.	100 Volts. Gas. Cu. Cen.
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	3.5	2.9	0.4	1.5	0.1	0.1	0.1	0.00
30	14.2	14.0	21.0	5.0	1.8	1.8	1.0	0.1
40	32.0	30.5	44.0	15.4	5.2	5.1	3.0	0.7
50	54	52	66.0	33.1	12.5	12	6.3	2.1
60	83	80	96.0	57	28	28	11.4	4.0
70	111	106	127	85	44	38	20.5	8.0

¹Area of the aluminium strips was ten square centimeters.

²Sodium hydrogen phosphate.

After being washed and allowed to dry, the strips were placed in a eudiometer with normal hydrochloric acid solution. The gas given off was read every ten minutes. These readings, taken at equal intervals, are plotted in the isochronal curves (plate III., direct current) with total cubic centimeters of gas as ordinates and as abscissæ the volts at which the aluminium plates were formed.

These curves show that the protective action is directly proportional to the voltage at which the plate is formed. As the time from the start increases, the rate of reaction increases. All the plates gave very little gas during the first ten minutes. The plates formed at lower voltages then quickly accelerated their rate of reaction, and those formed at higher voltage lagged behind giving off gas very slowly.

The very decided decrease in the corrosion of aluminium plates in hydrochloric acid would be still more pronounced in corrosion by sodium chloride. The author is of the opinion that utensils such as aluminium jars, cups, combs, etc., all kinds of aluminium handles could be coated with this film to ad-

vantage. Another field of importance is the treatment of electric lines of aluminium that are exposed along the sea coasts to the corrosive action of sodium chloride. Special treatment of the film has been found by the author to still further decrease the corrosive action of the chlorides upon aluminium. This article will be followed by others which will detail experiments upon the thickness, composition, mode of formation, mechanical and electrical properties of this film.

TABLE III.—ALUMINIUM PLATES FORMED WITH THE ALTERNATING CURRENT.¹

Volts. Min.	10 Gas. Cubic Cent.	20 Gas. Cubic Cent.	100 Gas. Cubic Cent.	150 Gas. Cubic Cent.
0	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00
20	0.5	0.2	0.1	0.1
30	4.5	2.0	1.0	0.4
40	14.5	6.0	3.4	1.0
50	35.0	15.5	8.5	1.6
60	69	35	21.7	2.2
70	107	65	50	3.2
80	160	109	99	4.0

¹Area of the aluminium strips was ten square centimeters.

In conclusion, it is my pleasure to thank Prof. Burgess at I Dr. Patten most heartily for favors and privileges extended me in carrying out this line of experiments. And, finally, I wish to express my lasting obligation to Professor Louis Kahlenberg for laboratory facilities, for his continued interest in my work and for the counsel and suggestions given me.

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THE DANIELL CELL AND THE GIBBS-HELMHOLTZ EQUATION.

By PROF. HENRY S. CARHART.

Mr. Woolsey McA. Johnson's paper in the March number of ELECTROCHEMICAL INDUSTRY contains an ancient error which should be given a decent burial. It is not an error of Mr. Johnson, but it is one that has been repeated in almost every paper and book in which the experimental confirmation of the Gibbs-Helmholtz equation has been the subject of comment and illustration since the appearance of Jahn's celebrated investigation relating to the Helmholtz principle. (Wiedemann's Annalen, Vol. XXVIII., pp. 21 and 491, 1896). I refer to the case of the Daniell cell as a confirmation of the Gibbs-Helmholtz principle. This principle has been established beyond question, but not by the Daniell cell. The data obtained from the Daniell cell are opposed to the conclusions of the Gibbs-Helmholtz theory. I do not doubt that if we had absolutely correct data for any specific solutions of the Daniell cell, they would be in harmony with the Helmholtz principle.

Mr. Johnson has given correctly the calories obtained by Jahn measured electrically in the one case and thermally in the other, with solutions consisting of $\text{CuSO}_4 + \text{H}_2\text{O}$, and $\text{ZnSO}_4 + 100 \text{ H}_2\text{O}$. For a half gram molecule they are 25.263 and 25.055 calories respectively. The electrical energy given out by the cell was therefore 0.208 calory greater than the heat of the reactions. The cell should then have a positive temperature coefficient. Now Jahn did not determine this temperature coefficient, but assumed a value given by Gockel. But Gockel's solutions were not the same as those of Jahn.

With concentrated copper sulphate solution the temperature coefficient of the Daniell cell decreases with the concentration of the zinc sulphate solution. Helmholtz says in his celebrated paper (*Sitz. der Wiss. Akad. zu Berlin* 1—1882, p. 24) that the temperature coefficient of the Daniell cell becomes zero with a

concentrated solution of copper sulphate when the specific gravity of the zinc sulphate solution is about 1.04. With a still weaker solution the coefficient may become positive. I have not been able to confirm Helmholtz's conclusion because of the interferences introduced by oxidation, especially when the cell is heated. No doubt remains, however, that with the solutions used by Gockel, the temperature coefficient is negative, while Jahn's data require that it should be positive.

The other six voltaic combinations investigated by Jahn confirm the Helmholtz principle in unmistakable terms; the difference between the electrical energy and the thermal energy of the Daniell cell is too small to be reliable as an indication either way. It would therefore be much wiser in quoting Jahn's results, to take some other case than that of the Daniell cell—a case where the results are so large as to be unmistakable.

WHAT AILED THE DYNAMO?

By C. O. MAILLOUX.

The caption "What Ailed the Dynamo" in the March number of *ELECTROCHEMICAL INDUSTRY* (page 86) attracted my attention, and I read the article with feelings of increasing surprise, amusement and also, I may confess, of impatience at the two "experts," so-called, of the electrical manufacturing company, one of whom went home "still thinking," while No. 2 was preparing his "tricks," to "test the insulation." Two experts, indeed! Two dromios, in a comedy of errors! Shades of John Hopkinson! That two amateurs—aye, two tyros—should have occupied the center of the stage in a two month's production of a farce suggesting, in name only, "Much Ado About Nothing," a serious drama of the immortal bard, must surely make Joseph Jefferson and Francis Wilson feel sad; they should have become "electrical experts" in order to reach the most exalted plane as comedians.

Of course, one does not need to be an expert, to see that if expert No. 1 had been able to "think" at all, if he had had any knowledge worth mentioning on the subject of armature reaction, it would not have taken him much time to diagnose this "ailment" as a plain, common and altogether natural (physiological, forsooth) case of armature reaction reaching or attaining an excessive degree which is incompatible with good commutation, as the result of a weakened magnetic field. Surely it would seem as if everybody at all familiar with the theory of the dynamo, ought to know as a fact and should understand the reason that the limiting load in amperes which a dynamo can carry without objectionable or injurious sparking—in other words, the limit of good commutation—decreases greatly as the magnetic field is weakened. It is, of course, possible by means of special designs and windings—notably the so-called "Sayers" winding, to obtain sparkless commutation with the full load current at very low e. m. f.'s., but it is not possible to obtain it with a machine of the usual type and design, when the magnetic field is reduced in the ratio of 80 to 120 (or two-thirds of its normal "strength"), unless the magnetic circuit has new mysterious properties in the particular case. Assuredly, the designing department of that large electrical manufacturing concern must have known better, and could have done a little thinking, even if neither of the alleged experts could.

The expedient finally adopted, namely, to maintain the magnetic field at full strength, as nearly as possible and to reduce the engine speed, is the correct remedy, as experienced electricians and dynamo-room attendants know very well. When the reduction desired in the e. m. f. is only relatively slight, it can usually be effected by cutting out the field shunt rheostat, so as to still obtain the full exciting current with a lower potential difference at the terminals of the shunt winding, and then reducing the rotative speed of the armature. When the reduction desired exceeds a certain limit, as in the case

described by Mr. Browne, the potential difference available at the terminals of the shunt winding would no longer suffice, even with all the resistance cut out at the rheostat, to produce the required full exciting current in the shunt coils; and it therefore becomes necessary, and is the most evident thing to do, to cut down the shunt resistance by reconnecting the coils, so as to have two sets in multiple, making the resistance of each set one-half as great as that of the whole shunt, and consequently making it possible to obtain the full exciting current with half the potential difference required for the whole shunt. The total exciting current will, of course, be twice as great, there being now two half windings in multiple.

The method suggested by Mr. Browne, to prevent reversal of the magnetic field, is obviously a proper one. It answers the purpose quite as well, however, to slightly reduce the load in amperes, before operating the circuit breaker, and it subjects the machinery to less strain. The general rule followed in all plants where several units are coupled together, would apply perfectly here, if we treat the vats as a "unit" having an e. m. f. of its own. The rule in *disconnecting* is simply to watch the ampere meter while manipulating the field resistance, so as to reduce the e. m. f., and, of course, the load (amperes) given out by the armature. When the load has fallen off to the proper amount, usually from 5 to 20 per cent of full load, then the circuit is opened either by the circuit-breaker or the main switch. In starting, the field is usually brought to full strength and the e. m. f. is allowed to attain its full value before the main switch is closed. In a case such as described by Mr. Browne, it would, perhaps, be better to excite the field only enough to give an e. m. f. sufficient to overcome any possible e. m. f. of "polarization" in the vats, say 40 or 50 volts; then close the main switch and "build up" the e. m. f. and the load until the desired current is shown by the ampere meter.

A DEVELOPMENT IN ELECTROLYTIC PRECIPITATION OF GOLD AND SILVER FROM CYANIDE SOLUTIONS.*

By E. M. HAMILTON.

This paper is not designed to reopen the old discussion on the respective merits of the electrolytic and zinc methods of precipitation, but merely to bring before the Society certain modifications in the Siemens & Halske process as originally worked in South Africa, which have been developed by Messrs. Charles Butters & Co., Ltd., in Mexico and the United States of America.

I think it was in 1899 that Mr. H. T. Durant was first engaged in working out these modifications at the Minas Prietas Reduction works of Messrs. Charles Butters & Co., in the State of Sonora, Mexico. He had made a start in this direction shortly before leaving South Africa, by experimenting with peroxidised lead anodes, but it was in Minas Prietas that most of the work was done.

The plant at Minas Prietas is of modern design, much after the style of the South African cyanide plants, with sands and slimes departments, and the method of slimes treatment is that usually adopted in plants under the control of Mr. Charles Butters, viz., the use of a single tank for the treatment of one charge, instead of transferring the charge from tank to tank, and the use of mechanical stirrers in addition to centrifugal pumps for agitation purposes. The capacity is about 9,000 tons a month, of which about 40 per cent would be slimes and the rest sands. The tailings being treated at the time referred to

*In our February issue we gave an extended review of the early developments of electrolytic precipitation of gold by the Siemens & Halske process, in South Africa, and notably of the work of Mr. Chas. Butters and his associates. Our former article may be read as an introduction to the above paper of Mr. Hamilton, which was recently presented to the Chemical, Metallurgical and Mining Society of South Africa. Dealing with recent developments and modifications of the Siemens & Halske process in America, Mr. Hamilton's paper gives important information, supplementary to the article in our February issue.—Ed.

were accumulated in dams after having been handled by the pan-amalgamation process, and for every dwt. of gold would carry, roughly, about 1 ounce per ton of silver, and also a variable amount of copper derived from the pan treatment.

When I arrived in Minas Prietas in July, 1900, I found the following precipitation plant in operation: Six boxes, each 30 feet long, 10 feet wide and 5 feet deep (with the bottom inclined to one side), and divided into twelve compartments, each of which contained 18 anodes and 17 cathodes. The boxes were placed in two rows of three, and the solution passed through two boxes in succession before reaching the storage tanks. Four of the boxes were used for slime solution, and the other two for sand solution; the current was supplied by two Siemens & Halske dynamos, each having a capacity of 250 amperes and 30 volts, and the current density was from 0.2 to 0.25 ampere per square foot of anode surface.

Before going into the details of working it will be well for me to state briefly the chief points of difference between this method and the Siemens & Halske process as originally worked.

1. The anode, instead of being made of iron, is composed of sheet lead coated with peroxide, and is not covered with canvas or enclosed in any way.

2. The metal precipitated is not plated on the cathode, but is deposited thereon in the form of a fine slime, which falls to the bottom of the box, and is cleaned up and dealt with exactly in the same way as the similar product from the zinc process. Now, as to the method of working.

Anodes.—The anodes above mentioned are sheets of lead about 3-16 inch thick, with a lead lug soldered on the corner of each, and a strip of wood along the top to strengthen it, and by which to suspend it in the box. It is coated with peroxide by being placed in a bath of permanganate of potash and connected with the positive pole of the dynamo for a given time.

After repeated trials under different conditions we find the following to be the most satisfactory way of making the anodes which we have as yet tried: The sheets of lead are received, cut to the desired size, then one corner of each sheet is scraped clean on both sides, and a cylindrical lug about $\frac{1}{2}$ inch in diameter, and 4 inches long (or a pair of such lugs) is cast onto the plate. This is done by means of a split iron mould with handles, somewhat after the style of the old-fashioned bullet mould, which is clasped and held on the corner while the molten metal is poured in from the top. It has been found advisable to add a small quantity of tin-solder to the lead used for the casting, so that it may have a slightly lower melting point than the lead plate, sufficiently so to avoid fusing the latter though, while at the same time being hot enough to make good junction at the surfaces of contact. The next thing done is the placing of the wooden support; we now put this on in one piece, instead of in two strips, as formerly. Lengths of wood about 1 inch square are grooved out of one of their sides to a depth of about $\frac{3}{4}$ inch, and 3-16 inch wide. These are then cut into short lengths the width of the plate, and the top edge of the latter placed in the groove, where it is secured by four or five wooden pegs driven through the wooden strip and lead sheet, and holding the two firmly together. The plate is now ready to be peroxidised. At Minas Prietas this is done in a special box, which holds only three plates at a time, but in the case of a new installation it would probably be found more convenient to fix up one of the working boxes for this purpose and do a large number at a time.

We have found that to get the best results the plate should be scratch-brushed immediately before being placed in the bath, so as to give a clean, metallic surface. The solution should be not less than 1 per cent of permanganate of potash in water, and should be maintained at this strength by frequent additions of the permanganate as the solution grows weaker; tests on it being made at intervals by titration with ferrous sulphate. The plates, when placed in the bath, are at once connected with the positive pole of a dynamo, the cathodes of the cell being

formed of similar lead plates, which, of course, remain there throughout. The current density used for the operation is 1 ampere per square foot of anode surface, and the minimum time of treatment is one hour. Anodes peroxidised in this way have been in use for the last ten or twelve months, and at the present time have as good a surface as on the day they were first placed in the box.

Cathodes.—At the outset the cathodes used were lead foil, cut into strips and hung on wires, as in South Africa. These were removed every day or two, and the deposit washed off with brushes under a stream of water, the cathodes being then replaced in the box. A large proportion of the deposited metal would also drop off the lead foil and fall to the bottom of the box, from which it was periodically cleaned up.

It will readily be seen that a thin, lead-foil cathode cut into strips would not long stand such an amount of handling as was involved in this method of cleaning, and very shortly after my arrival my attention was called to finding some form of cathode more suitable to our purpose. After experimenting with various metals, we have at length settled on a cathode of tin plate, which, up to the present, seems to work very satisfactorily. The material is simply good quality commercial tin-plate, and each cathode has a strip of iron about $\frac{3}{4}$ inch wide and $\frac{1}{8}$ inch thick riveted along the top edge, to support it in the box. The wire connecting it with the electrical circuit is soldered onto the surface of the plate, the other end being also soldered onto the copper tape which supplies the current.

The cleaning is done in the box by means of a kind of double squeeze, which, being slowly passed down the surface of the plate from above, wipes down both sides at the same time, and leaves the precipitate settled on the bottom of the box; each cathode is cleaned thus every day or two, as may be found necessary, the flow of solution being, of course, closed off during the operation.

The advantages of a tinplate as a cathode over the lead foil are as follows:

1. It is practically indestructible.
2. It can be cleaned down without being removed from the box.
3. It affords a means of perfect electrical connection with the copper leads, which was impossible when the cathode was a sheet of lead foil bent over a piece of iron wire. Anyone who has worked with the latter will know how very unsatisfactory used to be the connection and the consequent distribution of current.

For the periodical clean-up we have at Prietas to remove four or five anodes and cathodes in the center of each compartment but our new boxes at Virginia City Works, Nevada, U. S. A., are built with spitzkasten bottoms, so that neither anodes nor cathodes need ever be removed from their places, all that is necessary when clean-up comes round being to open a decanting pipe and run off the clear liquor, and then open a valve in the point of the bottom and run the precipitate wherever it may be needed, afterwards flushing out the inside of the box by means of a hose and a little clean water.

The deposition of the metal as a slime instead of a plating is effected by increasing the current density till it is in excess of its proper ratio to the amount of metal in solution and decomposition of water occurs, causing deposition of hydrogen on the cathode simultaneously with the metal.

The advantages of the foregoing modifications over the older method of work, as originally practiced in the Witwatersrand are as follows:

1. The absence of any action on the anode thus rendering it permanent, and avoiding byproducts formed by its dissolution.
2. As a consequence of the foregoing, a very wide latitude in the current density which may be employed, in contrast with the behavior of the iron anode, which rapidly succumbed to the effects of a high current.
3. The permanence of the cathode, which instead of being

melted down every month in order to recover the values deposited, remains in its place the whole time.

NOTES AND COMMENTS.

Current Strength.—The question of how to regulate the current so as to obtain the greatest efficiency with the least loss is a difficult though important one. It will be seen that though the anode will permit the use of a very high amperage, yet when the point necessary for the formation of a non-adherent deposit is reached, any additional increase of current will mean an increasing loss of effectiveness in such current, and also a reduction in the amount of cyanide regenerated, and possibly even a destruction of cyanide already free in the solution. We have to consider:

1. The amount of metal held in solution.
2. The amount of solution per hour running through the boxes.
3. The area of electrode surface.

In considering the variation of these quantities we have found the following tendencies:

1. If we suppose the electrode area and amount of solution per hour to be constant, and if we increase the amount of metal in solution we may then increase the current in proportion and get so much more metal precipitated.

2. But if, on the other hand, we keep the area and amount of metal per ton constant, and increase the quantity of solution, a corresponding increase of current gives a disproportionate and continually diminishing effect.

3. If again, we retain the same quantity of solution per hour and the same value of solution, but increase the electrode surface an equivalent of the same current density as before (only spread over a greater area, and therefore proportionately less) will give a greater efficiency in metal precipitated. Thus, even in our modified method of working, Mr. von Gernet's statement on this subject will still to a great extent hold good. At a meeting of the Chemical, Metallurgical and Mining Society of South Africa, on August 18, 1894, in a paper on "Electrical Precipitation of Gold," after calling attention to the fact that, owing to the weakness in metal of ordinary cyanide plant solutions an artificial diffusion of the liquid is necessary, he says, "but it is still more important to give a very large surface to the electrodes. In fact, a better effect is obtained by doubling the number of plates than by increasing the current tenfold."

The tendency would appear to be, then, that the current strength ought to vary as the amount of metal in solution, but that the electrode area should vary as the quantity of solution or speed of flow. The last case, viz., the determination of the electrode area, will also be influenced somewhat by the amount of metal in solution—to this extent, that, as Mr. von Gernet points out, a solution weak in metal will need a much larger area than one rich in metal—but from an electrolytic point of view we might class all solutions from a cyanide plant as being "weak in metal," so that variations in area due to this cause will be very small as compared with those necessitated by variations in the amount of solution passing per hour.

What the ratio is between anode area and amount of solution is difficult to determine. Of course, it is easy to find out in any given case by experiment what ratio will give the best practical results, but we have not yet succeeded in establishing a rule applicable in general. Nor does Mr. von Gernet help us much on this point. In the above-mentioned paper he states that to precipitate 100 tons of solution (containing 5 dwts. of gold per ton) in twenty-four hours 10,000 square feet of cathode surface are necessary, but he does not say how this figure is obtained, nor under what circumstances and to what extent it is variable. Of course, working as we do for a non-adherent deposit, we can make up for deficiencies in electrode area to some extent, by raising the current density, but this, as

I have already pointed out, is a wasteful proceeding, and to be avoided, if possible.

The correct relation of quantity of solution to electrode area, i. e., the most economical adjustment of one to the other, is a question I am obliged to leave unanswered for the present for want of sufficient data. I will, however, give some working figures from the Prietas plant to illustrate my contentions in this section of my paper. I will take for this purpose November and December, 1901, because I happen to have the figures for those months by me, and am writing at a distance from Prietas.

1. **Solutions from Sand Treatment.**—The total anode area for dealing with this solution was 6950 square feet, and the average flow per hour 9 tons, or 216 tons per twenty-four hours. Putting this into the same terms as Mr. von Gernet's estimate, we have 3217 square feet to precipitate 100 tons of solution per twenty-four hours. (In the present case anode area is equivalent to cathode area.) The other conditions were as follows: Current density, 0.55 ampere per square foot; voltage between the electrodes about 3 (varying slightly in different compartments). Value of solution, average over the two months in question:

Entering.		Leaving.		Percentage precipitated	
Gold dwts.	Silver ozs.	Gold dwts.	Silver ozs.	Gold	Silver
2.93	3.51	0.26	0.29	91%	91.7%

Thus the total value of the tail solutions was equivalent to about 10 grains of gold per ton. As we never used this solution for final washes, we did not think it profitable to spend more power in reducing the value any lower.

2. **Solutions from Slime Treatment.**—The total anode area allotted to this solution was 13,536 square feet, and the average flow per hour 20 tons, or 480 tons in the twenty-four hours. Thus, to precipitate 100 tons of solution per twenty-four hours we were using 2818 square feet of anode. The current density was 0.3 ampere per square foot; the voltage between the electrodes about 2.6. Value of solution, average over two months:

Gold.		Silver		Gold		Silver	
dwts.	ozs.	dwts.	ozs.	dwts.	ozs.	dwts.	ozs.
1.10	1.45	0.13	0.15	88%		89.6%	

or a total tail value equivalent to about 5 grains of gold per ton. On several occasions during this period it happened that the flow of solution was cut down to about two-thirds of the normal flow, for a day or two at a time, with the following result in assay value of outflow: Gold, 0.05 dwts.; silver, 0.06 ozs. Whether, owing to re-solution of metal, or to mechanical losses of impalpable slime in suspension, this is about the lowest tail value we ever succeeded in getting at Prietas, being approximately equivalent in value to 2 grains of gold per ton.

The foregoing will give a rough idea of the ratio between electrode area and quantity of solution which may be expected to give workable results under conditions similar to those described. I will next give a few figures on tests I have made, illustrating the effect of some varying conditions in the boxes.

FIRST EXPERIMENT.

The solution from the slime plant was divided into two equal streams, and treated under two different systems.

System No. 1.—Half the above solution was run through two boxes in tandem, which were in the same circuit and run by a separate dynamo, and were furnished with a current of 0.3 ampere per square foot. (This dynamo was indicating 250 amperes and 25 volts.)

System No. 2.—The other half of the solution was run through a single box, wired so as to give 0.7 ampere per square foot and also having its own dynamo, which indicated 200 amperes and 38 volts.

Thus the amount of solution and its value were the same in

each case, but in No. 2 there was one-half the electrode surface and more than double the current density of No. 1. The average assay over ten days was as follows:

Inflow.		Outflow.	
Gold, dwts.	Silver, ozs.	Gold, dwts.	Silver, ozs.
1.30	1.56		
System No. 1.		System No. 2.	
Gold, dwts.	Silver, ozs.	Gold, dwts.	Silver, ozs.
0.15	0.16	0.23	0.25

Thus, not only did the increase of current density not make up for the deficiency in surface in No. 2, but it also caused a waste of power, using 7600 watts as against 6250 watts for No. 1 system, or nearly 2 hp. more. The test shows, however, that deficiency in area can be largely compensated for by increase in current, though the remedy is not economical.

SECOND EXPERIMENT.

The current density in system No. 2 was raised to 0.8 ampere per square foot. Average assays over three days:

Inflow.		Outflow.	
Gold, dwts.	Silver, ozs.	Gold, dwts.	Silver, ozs.
1.46	1.70		
System No. 1.		System No. 2.	
Gold, dwts.	Silver, ozs.	Gold, dwts.	Silver, ozs.
0.17	0.20	0.23	0.26

It would thus seem that the current used in the first experiment, system No. 2, was about the limit, beyond which any increase had practically no effect on the value of the outflow.

approximately the extent of such waste. The total gold, silver and copper from each box cleaned up was carefully estimated, including values in slag. This total was then divided by the number of ampere hours required to produce it, and the result compared with the theoretical amount of metal which might have been deposited, determined by taking the theoretical rate of deposition for the three metals, gold, silver and copper, in the proportion in which they were deposited, and making an average of them, and then calling such an average the theoretical rate of deposition of such a gold-silver-copper alloy. For instance, in the case of one box (the first sands box) the average proportion of the metals cleaned up during two months was as follows:

Gold	3.16%
Silver	81.14%
Copper	15.7 %

Then if the theoretical rate of deposition per ampere hour be

For gold (monovalent)	113.17 grains
For silver (monovalent)	62.11 "
For copper (bivalent)	18.62 "

the weight of gold-silver-copper theoretically capable of being deposited by 1 ampere in one hour would be (in this box) 56.83 grains. Thus we need a different theoretical standard for each box, according to the proportion in which the three metals are precipitated. Before giving the results of this test in table I. it will be well for me to explain what the different boxes are which are there mentioned. No. 3 is the first box to receive the solution leaching off the sands plant. On leaving the tail of box 3, this solution passes directly into No.

TABLE I.
Taken over two months, November and December, 1901.

Box Number.	CLEAN-UP FROM ALL SOURCES (OUNCES TROY)				Total Number of Ampere-Hours.	Grains of Gold-Silver-Copper Actually Deposited per Ampere-Hour.	Grains of Gold-Silver-Copper Theoretically Capable of Being Deposited per Ampere-Hour in this Box.	Theoretical Percentage of Amperage Wasted.
	Gold. Ounces.	Silver. Ounces.	Copper. Ounces.	Total. Ounces.				
No. 3.....	1,336	34,297	6,633	42,266	2,698,104	7.52	56.83	86.76
No. 6.....	410	10,388	4,678	15,476	2,453,808	3.02	50.19	93.90
Nos. 1 and 2..	775	20,840	15,139	36,754	2,821,778	6.25	45.12	86.10
Nos. 4 and 5...	208	5,368	6,477	12,053	3,029,950	1.90	39.41	95.17
Totals.....	2,729	70,893	32,927	106,549

THIRD EXPERIMENT.

No. 1 system remained as in the previous test, but No. 2 system was composed of two boxes, in tandem, wired so as to give a current density of 0.37 ampere per square foot. (Dynamo for No. 2 indicated 240 amperes and 35 volts.) Average assays over ten days:

Inflow.		Outflow.	
Gold, dwts.	Silver, ozs.	Gold, dwts.	Silver, ozs.
1.21	1.54		
System No. 1.		System No. 2.	
Gold, dwts.	Silver, ozs.	Gold, dwts.	Silver, ozs.
0.13	0.14	0.14	0.16

Thus, with equal electrode surfaces, there was absolutely nothing gained by expending an extra 3 hp. on current, tending to show that in system No. 1, other conditions being equal, 0.3 ampere per square foot was the maximum which could be profitably employed. I have figures of other experiments showing in the main, similar results, but to describe them all would unduly draw out my paper.

Waste of Current.—It will be obvious that the current used under the foregoing conditions will be very much in excess of the theoretical amount necessary to deposit the quantity of metal present.

Figures were kept for two months to try and determine

6, and from the tail of No. 6 into the storage tank. Boxes 1 and 2 are those into which the solution from the slimes plant first runs; and from the tail of 1 and 2 this solution passes into 4 and 5, and so out to the storage tank.

The current was supplied by three dynamos, and the current density was for slimes solution 0.3 ampere per square foot of anode, and for sands solution 0.55 ampere per square foot.

It will be seen that the current used is enormously in excess of that theoretically necessary but in considering this method of precipitation as compared with others, account must be taken of the fact that the item of power is practically the only expense involved; and as we shall see in the following section, a part even of this expense is offset by the value of the free cyanide which is regenerated during precipitation. The average current leaving the dynamo during the two months covered by the test was 25,626 watts, or about 34 hp., and requiring actually about 50 i. h. p.

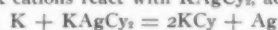
REGENERATION OF CYANIDE.

Before giving any figures under this head, I will quote a passage from Mr. Walter McMillan, which may help to explain what occurs during precipitation. ("A Treatise on Electro-Metallurgy," by Walter McMillan; second edition. Charles Griffen & Co., Ltd.) Page 198:

"In passing the electric current through a solution of silver

potassium cyanide ($\text{KAg}(\text{CN})_2$), the double cyanide is broken up into the cation K, and the anion, $\text{Ag}(\text{CN})_2$. The potassium is deposited at the cathode, but by chemical exchange displaces from the surrounding solution of the double cyanide an equivalent of silver (which deposits on the cathode) and forms potassium cyanide in the liquid (thus: $\text{KAg}(\text{CN})_2 + \text{K} = \text{Ag} + 2\text{KCN}$). Thus there is a centration of potassium cyanide around the objects which are being plated. The silver travels in the anion $\text{Ag}(\text{CN})_2$ to the anode, where the ion decomposes into $\text{AgCN} + \text{CN}$, and the cyanogen (CN), set free, attacks the silver anode to form another molecule of AgCN . Hence, at the anode there is formed a double quantity of the insoluble compound AgCN . It is therefore necessary that a good excess of free potassium cyanide be present, to combine with the silver cyanide (which would otherwise form an incrustation on the anode) and thus to form the soluble double cyanide, whereby the silver is carried into solution and the anode is left bright throughout." Again, on page 360, the same explanation is given in the case of potassium auro-cyanide.

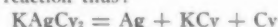
Now, the foregoing reactions are given with reference to a soluble anode, but if we suppose the anode to be an insoluble one, the result would appear to be as follows: At the cathode the K cations react with KAgCy_2 , according to the equation



at the anode the anion AgCy_2 splits up according to the equation



Thus, at the end of the reaction we have on the cathode side Ag (which remains on the cathode), and 2KCy in the solution; while on the anode side we have AgCy and Cy . If, then, we take one molecule of KCy from the cathode side and combine it with AgCy on the anode side, we have KAgCy_2 ; so that when the anode is not soluble we have one molecule of KCy left free in the solution (representing potassium cyanide regenerated) and also Cy . So that we might summarise the total reaction thus:



showing for every molecule of potassium-silver cyanide a regeneration of one molecule of potassium cyanide.

TABLE II.—SANDS SOLUTION.
Average Strength in KCN.

MONTH.	Tail of Box. Per Cent.	Head of Box. Per Cent.	Increase. Per Cent.
September, 1902.....	.10745	.09618	.01127
October, 1902.....	.08329	.06835	.01494
November, 1902.....	.09305	.06732	.02573
December, 1902.....	.09400	.08357	.01042
January, 1903.....	.09123	.08061	.01062
Averages.....	.09380	.07920	.01460

SLIMES SOLUTION.
Average Strength in KCN.

MONTH.]	Tail of Box. Per Cent.	Head of Box. Per Cent.	Increase. Per Cent.
September, 1902.....	.06254	.04654	.01600
October, 1902.....	.05235	.04164	.01071
November, 1902.....	.05458	.04200	.01258
December, 1902.....	.04343	.03614	.00729
January, 1903.....	.05046	.03800	.01246
Averages.....	.05267	.04086	.01181

In the above reaction it is assumed that the current density is in proper proportion to the metal present in solution. Should, however, the current be in excess, or, in other words,

should K be deposited on the cathode so fast that it cannot find enough of the potassium-silver cyanide in the neighborhood of the cathode to react upon, the excess will decompose water and deposit hydrogen, and the amount of KCy finally regenerated will be diminished. Now, as to actual results obtained. Regeneration of cyanide is a phenomenon which is very noticeable when working under the conditions described above, though I do not remember that it attracted attention during the discussion on the electrolytic process in South Africa, where indeed it would not be likely to be in evidence owing to the difference in conditions of working. On a few occasions when working on the Rand, I noticed a slight rise in cyanide strength after the solution had passed through the box, but in each case it was so small that it might have been accounted for by a difference in the finishing point of the titration, and I did not follow it up by making any systematic tests. At Prietas, however, where my attention was first called to it by Mr. Durant, I have made repeated experiments to verify this, the test in one case running over five consecutive months; the results are given in table II. (samples taken by hand every two hours, and test made on each day's composite sample).

From table II. it will be seen that the average increase in strength caused by passing through the boxes (taken over five months) was:

For sand solution 0.0146% KCy

For slime solution 0.0118% KCy

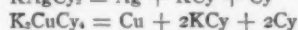
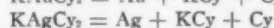
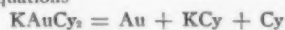
or, in other words, for every 100 pounds of solution which passed through the sand solution boxes 0.0146 pound of KCy was regenerated, and for every 100 pounds passing the slime boxes 0.0118 pound of KCy was regenerated. Now, the relation of the amount of ore treated to solution going through the boxes was: For sands, 1.2 tons of solution per ton of sand; and for slimes, 4 tons of solution per ton of slime, so that for every ton of sand treated we recovered 0.35 pound of cyanide, and for every ton of slimes 0.94 pound. Then, if the slimes be taken to constitute 40 per cent of the tailings treated, we have a total saving in cyanide of 0.58 pound per ton of ore treated during the period covered by the test. (I may here mention incidentally that the total average cyanide consumption on the plant was from 2.5 to 3 pounds per ton of ore.)

The difference in cyanide recovery between sands and slimes is very noticeable, and the following would seem to be the way to account for it: From the precipitation table I. it will be seen that the slime boxes yielded nearly double the amount of copper which was recovered from the sand boxes; if, then, this copper be considered to be in solution in the cupric form, one ounce of it would furnish about three times as much KCy as a similar weight of silver, and about six times as much as a similar weight of gold. Table I. does not cover the same period as table II. on cyanide regeneration, but is sufficiently representative to be used as an illustration. If the weights of gold, silver, and copper precipitated in the sands and slimes boxes, respectively, be considered in regard to the possible KCy they could furnish in the act of being precipitated, the slimes box will have a very marked advantage, especially when it is remembered that this box only deals with 40 per cent of the total tonnage of ore treated.

In order to see how the amount of cyanide actually recovered per ton of ore compared with the theoretical amount capable of being regenerated in accordance with the foregoing reaction, the total gold, silver and copper precipitated during the five months covered by this test was divided by the total number of tons treated. This gave an average of

Gold, ozs.	Silver, ozs.	Copper, ozs.
0.12	2.57	5.88

precipitated per ton of ore treated. Then, taking as a basis the equations



we have a cyanide regeneration of 0.93 pound per ton of ore treated, as against 0.58 pound actually recovered per ton of ore.

Now the theoretical figure taken, if correct, could only be so when the current is so adjusted as to cause no decomposition of water; but, as a matter of fact, there is in the boxes a very lively decomposition of water, and therefore a loss of available potassium cyanide, KOH being formed at the cathode and H being liberated; and such loss would seem to be far greater than the difference shown between the actual and theoretical amount of KCy regenerated; consequently, it would seem legitimate to suppose that the Cy shown to be liberated at the anode combines to some extent with the KOH in the solution to form free KCy, thus:



In this case, there would be going on simultaneously a very active decomposition and recombination of free KCy, and our free cyanide actually shown by test to be recovered would represent the difference between these two tendencies.

Mr. M. F. Perry, the general manager at the Minas Prietas Works, informs me that lately, since they have been treating the ore direct from the mine, without any previous amalgamation or concentration, the regeneration of cyanide has decreased very considerably. One cause which would make this more apparent, would be the absence of copper in the solution. The only other difference in conditions would seem to be the increase in the amount of silver sulphide in the ore. I have heard several cyanide chemists give it as their opinion that, in the case of treating Ag₂S with potassium cyanide, the silver sulphide is decomposed and gives up its sulphur to the potassium; but Dr. Rose ("Metallurgy of Gold") states reasons for believing that silver sulphide is in some cases directly soluble, without decomposition, in strong (and even in weak) solutions of cyanide. It is difficult to suggest reasons for the decrease in regeneration of KCy in the present instance without knowing exactly in what form the silver comes into the boxes.

LIME PRECIPITATION.

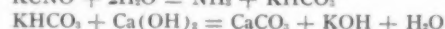
One drawback we have encountered in working out this method is the precipitation of the lime held in the solution. It is chiefly noticeable in the slime solution boxes, and more especially the second set, into which the solution flows after leaving the first set of boxes. It has sometime formed as much as 30 to 40 per cent of the precipitate cleaned up from these boxes, and, of course, has added very much to the difficulties of smelting. An incrustation, chiefly composed of calcium carbonate, also forms on anodes, which have not been thoroughly peroxidised. The anodes we made during the first two years or so gradually wasted away, and in the process accumulated the heavy white crust above mentioned; but, as I said in the first section of this paper, anodes peroxidised under the conditions there stated, have, up to the present, shown no change of surface, whatever. An analysis of this crust, made for me by Messrs. Lehman, of Baltimore, Md., showed the following constituents:

Moisture	0.275 per cent
Loss upon ignition	6.060 "
Calcium oxide	41.580 "
Carbonic acid	31.120 "
Lead metallic	13.530 "
Iron oxide	0.540 "
Copper metallic	0.750 "
Sulphuric acid	4.400 "
Chlorine	0.670 "
Vanadium	0.095 "
Silver	0.125 "
Gold	0.003 "

99.149 per cent

Why the lime is thrown out of solution, I am unable to

say; it might be possible to represent the reaction by the following:



A smell of ammonia is often distinctly perceptible in the atmosphere around the boxes, especially those in which most lime is precipitated. But the above explanation would not appear to be sufficient to account for the facts if it indicates nothing more than a substitution of potassium hydrate for calcium hydrate in the solution, for this reason: when trying various methods to reduce the amount of lime in the precipitate, I cut down the free lime in the working solutions to the lowest point compatible with proper settlement of the slimes. Under these conditions, solution which showed 0.005 per cent of lime (by alkalinity test) when going into the boxes, did not show a trace of free alkali after passing through. This last fact would, perhaps, point to a decomposition of KOH by the Cy liberated at the anode, as suggested in the preceding section. If this should be so, the addition of caustic potash at the head of the box might result in an increase of free cyanide regenerated. I hear that Mr. Clive Newcomb, who now has charge of the precipitation of Prietas, is experimenting with a drip of caustic potash with this end in view, independently of any suggestions contained in this paper, but I have not received any figures on this test.

As regards the lime, it is possible that CaCO₃ is not formed in the first instance, but that the calcium combines directly with the Cy at the anode to form CaCy, which then undergoes further changes.

The only way we have so far found to abate the nuisance is to reduce the current density employed; the tendency increases with increase of current, and *vice versa*. This would be another reason, in addition to those given in earlier sections of the paper, for having sufficient electrode area to be able to use the lowest current density compatible with a proper sliming of the metal precipitated.

CONCLUSION.

As regards the usefulness of this method of electrolytic precipitation it is possible that it would not be advantageously applied in the case of a proposition where the metal to be deposited is almost exclusively gold—this could only be found out by trial—but where the values are largely composed of silver (implying a considerable weight of metal to be thrown out of solution) it would seem likely to be very serviceable, and in cases where large quantities of copper are dissolved in company with the gold and silver, the method would probably be found exceedingly valuable.

As regards the data given in this paper, I have taken pains to make them as correct as possible, and I think they can be taken as accurately representing the facts. In carrying out experiments and obtaining the above-mentioned data, I have to acknowledge the valuable assistance, first, of Mr. W. Mosher and later, of Mr. Charles Morgan, and Mr. Harry Freiburger.

Copala, Smaloo, Mexico.

METRIC SYSTEM IN MEXICO AND IN CUBA.

In a consular report from Durango, Mexico, it is stated that the metric system has been very generally adopted by the people in Mexico, and is in use in ordinary practice, as well as being the official measures of weight and capacity. In the building trades, for example, the meter is the ordinary standard for linear, square, and cubic measure, and the ordinary workmen in the carpenter's, stone cutter's, and brick or adobe layer's trades use the meter rule for their work as a general thing. In smaller carpenter shops they still express themselves for purposes of comparison in Spanish feet and inches (*pulgadas*) at times, but the meter rule is their

guide and smaller measures are ordinarily determined in centimeters. The architects of the country have in the main adopted the metric system; the exceptions to this rule are American or English architects who are temporarily engaged in putting up buildings here, and who quite generally cling to the old measures familiar to them. The Mexican National Iron and Steel Company (which operates the "Iron Mountain" here) turns out iron for structural purposes both in feet and meters, according to the way the plans are drawn. Their manager states that architects from the United States generally express their measurements in feet.

In a report of Consul M. J. Baehr, of Cienfuegos, Cuba, it is stated that the metric system of weights and measures is established by law and is adopted in all transactions at the custom house, city hall, and in the registry and records of property; in fact, it is compulsory and adhered to in all official acts. In ordinary life, however, in groceries, in the sale of the country's products, such as cereals, the pound is still adhered to. Civil engineers and land surveyors in Cuba employ the metric system throughout their measurements. Mechanics in general make use of English inches as their unit measure.

THE RELATION BETWEEN ARSENIC AND ELECTRO-MOTIVE FORCE IN COPPER-ELECTROLYSIS*.

By L. WEBSTER WICKES.

The bad effects of arsenic in commercial copper are well known to metallurgists. The refining of copper by electrolysis eliminates practically all of the arsenic, provided certain requirements are fulfilled. The first, and most important, of these requirements is that the voltage of the depositing current shall not be too high. It has been known for some time that the percentage of arsenic in the deposited copper increases with the voltage.

To investigate the relation between the e. m. f. and the freedom of the precipitated copper from arsenic, the experiments were made, of which a brief summary is here given. I made three copper-arsenic alloys, containing respectively 3.56, 2.24 and 0.66 per cent of arsenic. From these alloys I cast several anodes. For cathodes I used sheets of thin copper, coated on one side with "mounting wax," and on the other with a thin film of graphite. Vaseline was used to make the graphite adhere. During electrolysis the copper was prevented from depositing on one side of the cathode by the wax, while the copper deposited on the other side was readily stripped off to be weighed, analyzed, etc. The electrolyte used was that suggested in Peters' Modern Copper Smelting, viz.: $\text{H}_2\text{O} \div \text{CuSO}_4 \div \text{H}_2\text{SO}_4 = 75 \div 19 \div 6$. The electrodes were 6 by 8 inches, resting in 5-liter vulcanite vats. Electrolytes were circulated by air.

I set up three sets of three vats, each connected in series, and each containing an anode from each of the three alloys. The current used in each set of three cells was so regulated that the cell-drop of the first set was 0.8 volts; of the second, 0.6 volts; and of the third set, 0.4 volts.

The amperes of the first set were 5.5, and of the second and third were 4. The difference in voltage of the second and third was obtained by decreasing the distance between electrodes.

The question was raised, whether the higher voltage, due to the greater distance between the electrodes, would have the same effect as increasing the voltage by increasing the current, and keeping the cell-resisting constant? Undoubtedly increasing the e. m. f. by increasing the current changes the drop from anode to solution, and from solution to cathode,

as well as through the solution. But, since the energy set free by the solution of a metal is equivalent to that required to precipitate from the solution, they will always balance each other.

I found that, with different voltages, but with the same percentage of arsenic in the anode, the percentage of arsenic in the cathode per weight of copper is practically the same, whether the difference of voltage is due to difference in the distance between the plates, or to difference in amperage.

I set up four more vats, using the 2.24-per-cent-arsenic alloy for anode in each. To the electrolyte of each was added 0.101 per cent As in the form As_2O_3 . The first of these cells had 2.5 inches, and the second 1.5 inches between the plates; and passing 4.5 amperes through the first, and 9.5 amperes through the second, gave them an equal cell-drop of 0.95 volt. The electrolyte was the same in both. In cell No. 3 a less acid electrolyte was used than in cell No. 4 (other conditions being the same as in Nos. 1 and 2), but brought up its conductivity to that of No. 4 by the addition of potassium sulphate. The cell-drop of each was 0.95 volt when No. 3 had 2.5 inches between plates and 4.5 amperes, and No. 4 had 1.5 inches between plates and 9.5 amperes. No. 3 was kept quite warm.

Two important facts were noted:

1. Whenever the main current was shut off, a certain voltage was always shown in the cell.
2. This voltage was always in the same direction as the original current.

Of the four cells last described, the percentage of arsenic per weight of copper was less in No. 3 than in No. 1, and less in No. 1 than in No. 2 and No. 4.

Since a certain voltage was shown in the cells when the main current was interrupted, and that said voltage being in the same direction as the main current voltage, it is evident that, as the electrodes are identical with the exception of the arsenic, the arsenic passed into solution as cations, or out of solution as anions. In either case the result is the same. It is impossible for anions to exist on the cathode. Therefore, to produce this voltage, the arsenic must pass into solution as metallic arsenic, and from the solution it becomes sulphate. To be deposited on the cathode, it must continue to exist as cation. In this water solution the arsenic hydrolyzes and becomes arsenate. When hydrolyzed it cannot be deposited. Hydrolyzation is a function of the time the ion is in contact with the solution. In other words, the more time the arsenic has to hydrolyze, the smaller will be the percent of arsenic in the deposited copper. As the amperes increase, the time for hydrolyzation decreases. The hydrolyzation in cell No. 3 was greater than that in No. 1 (less acid and warmer), while both gave greater length of time than Nos. 2 and 4.

From the above, I think it follows that the percentage of arsenic in the cathode is only indirectly a function of the voltage in so far as that is a function of the amperage, and is directly a function of the degree of hydrolyzation of the sulphate. The investigation of the exact limit to which the hydrolyzation of the arsenic sulphate could be carried without the production of the copper oxide, I was forced to abandon for the time being.

The arsenic was added to the second group, consisting of the four cells, to bring the electrolyte up to the condition it would be in after a considerable run. The arsenic in the successive cathodes was not increased thereby, as is the case with electrolytes high in arsenic, due to a long run. This fact would seem to indicate that the arsenic in the solution, after a run, was not in the form of As_2O_3 . Mr. W. McA. Johnson, in one of his papers,¹ says that "The oxide of arsenic present in an anode is an insulator, and thus passes into the slimes." The arsenic seems, therefore, to have another "phase." So far, this has not been investigated. Another question which I have so far been unable to answer is, what effect has the condition in which the arsenic exists in the

*Paper presented at the Atlantic City meeting of the American Institute of Mining Engineers. It is an abstract of a thesis presented, in partial fulfillment of requirements for the degree of metallurgical engineer, to the Faculty of Applied Science, Columbia University, New York city. The full text of this thesis, with tables, curves, etc., is in the library of the Department of Metallurgy at the university, and may be consulted by those desiring more detailed information.

¹Transactions of the American Electrochemical Society, vol. I., p. 173.

anode on its distribution throughout the cathode, electrolyte and slimes, or its combination with silver, etc.? A careful research in this field, as well as along the line of the form or phase of the arsenic during the different stages, will be necessary before definite conclusions can be reached.

The opinions here brought forward are the result of the analysis of nearly 200 depositions of cathode copper, and electrolytes. The experiments were carried on in the Department of Metallurgy of Columbia University, to which I am greatly indebted for the opportunities offered, as well as to Professors Morgan and Miller, of the Department of Chemistry, for much valuable help and many suggestions.

ALUMINIUM: A NEW PROCESS OF M. GUSTAVE GIN.

By P. McN. BENNIE.

For almost a century inventors have struggled with the problem of extracting that widely distributed element aluminium from the various compounds in which it occurs. Many processes have been conceived, some impossible, others impracticable, and still others too costly to ever find commercial application. The prize of a successful process has been sought most zealously, but finally the field has narrowed down to two processes which have survived the supreme test of successful commercial application, those of C. M. Hall and Paul Héroult.

One would think that almost every experiment in the gamut of possibility had been thought of and tried, but still the search goes on. A number of processes have been patented within the last two years, by Hohman, Rubel and Bernstein, Reuterdaahl, Blackmore, Schwahn, Jensen, and others. Gin¹ proposed to produce aluminium by decomposition of an electrolyte consisting of a mixture of molten aluminium fluoride and sodium sulphide. Taddei² proposed to electrolyse fused sodium chloride, bring the chlorine into contact with a mixture of tar and dehydrated alumina, form aluminium chloride and carbonic oxide, and then pass the aluminium chloride in the form of vapor into another vessel, where it would come into contact with sodium vapors generated by the primary step in the process; the sodium combining with the chlorine of the aluminium chloride, forms sodium chloride and free aluminium.

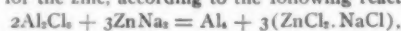
M. Gin has recently patented still another process,³ which seems to attack the elusive problem in a different way. The interest which attaches to aluminium processes generally seem to justify some notice of the process, which has been reviewed at length by M. Becker, in *l'Industrie Electro-Chimique*, for December, 1903.

The process of Sainte-Claire-Deville for the manufacture of aluminium, which had been in operation in France at Nanterre and Salindres, was finally abandoned on account of the high price of sodium, and aluminium chloride.

Grabau⁴ appears to have been one of the first to conceive an advance towards a commercial process, by proposing the addition of sodium chloride to the electrolytic bath, as furnishing simultaneously the alkali reducing metal (sodium), and the chlorine required for the preparation of aluminium chloride.

Others,⁵ among whom were Basset & Seymour, have claimed to substitute zinc for sodium, as reducing agent, by observing that, while zinc does not decompose pure aluminium chloride, it reduces the double chloride of aluminium and sodium, at a red heat. Basset obtained in this way an alloy of zinc and aluminium. This reaction was never applied industrially, and does not seem to have been commercially practicable.

M. Gin claims, however, that it is easy to effect the reduction of aluminium chloride, by the substitution of zinc-sodium alloy for the zinc, according to the following reaction:



by using simultaneously the zinc and sodium for the reduction.

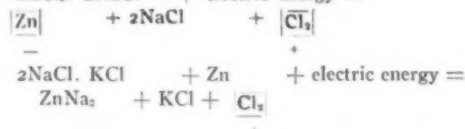
Thermochemistry shows that at temperatures higher than the point of volatilization of the double chloride of aluminium and sodium—but still inferior to that of the double chloride of zinc and sodium—the system $2\text{Al}_2\text{Cl}_6 + 3\text{ZnNa}_2$ has a potential energy greater than that of the system $\text{Al}_4 + 3(\text{ZnCl}_2 + 2\text{NaCl})$. It is therefore the latter which is formed by virtue of the principle of "maximum work."

It is admitted that the economy resulting from the substitution of the zinc-sodium alloy for pure sodium, is not sufficient, and that it is desirable to render the preparation of the aluminium chloride more economical by starting directly—not with pure alumina, but with bauxite, the least costly of the minerals of the aluminium series.

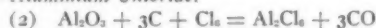
Upon these principles M. Gin has based a process for the manufacture of aluminium, consisting of the reduction by zinc-sodium alloy, of aluminium chloride prepared from bauxite by means of the chlorine disengaged by the same electrolytic operation which furnishes the zinc-sodium alloy.

The reduction which finally yields the metallic aluminium also reconstitutes the double zinc-sodium chloride in such fashion that the various operations form a closed cycle, with regeneration of the intermediate compounds, of which the successive phases may be illustrated by the following formulæ:

I.—Chlorine and Zinc-Sodium.



II.—Aluminium Chloride.



III.—Reduction by Zinc-Sodium.



In order to show how this is carried out in practice, M. Gin describes in detail the various phases of manufacture.

The chlorine and zinc-sodium alloy are prepared by electrolysis on one hand of the double chloride $\text{ZnCl}_2 \cdot 2\text{NaCl}$, and on the other the chloride $2\text{NaCl} \cdot \text{KCl}$. These two operations disengage chlorine, the first supplying the zinc destined for the cathodic bath of the second, in which is prepared the alloy ZnNa_2 (about 40 per cent of sodium).

The electrolysis is carried out with a cathode consisting of an iron crucible, lined with agglomerated carbon; the anode consists of a bundle of cylindrical carbons. These carbons are fitted at the upper end into a cap, or holder, having the form of an inverted box, of which the lateral walls are grooved into a channel surrounding the crucible, and filled with water so as to form a hermetically sealed hydraulic joint. It is said that the best results are obtained by conforming to the following values:

	Zinc.	Sodium.
Density of current at cathode	0.25	0.50
Density of current (cross-section of anodes)	1.00	2.00
Temperature of system	450°C.	580°C.
Voltage of system	3.7 to 4	6.6 to 7

M. Gin admits that the electrolytic apparatus for the manufacture of sodium and its alloys are very numerous and well known, through the work of such men as Rogers, Vautin, Borchers, and others. He does not claim either the principle of electrolytic preparation of zinc-sodium, or the apparatus described, as any other arrangement may be substituted, providing it conforms to the conditions given.

¹British Patent 964, 1903.

²U. S. Patent 715,625, December 9, 1902.

³French patent 834,132, July 25, 1903.

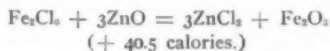
⁴Electric Smelting and Refining, second edition, Borchers.

⁵For instance, Kagenbusch, English patent 4,811, 1872.

While theoretically the zinc chloride should be reformed during the course of the operations, it is necessary to add regularly a certain quantity to compensate for losses due to divers causes, notably to the fixation of chlorine by the iron and silica of the bauxite.

The zinc chloride may be obtained in various ways, but it is found that the most economical method consists in submitting zinc blende, as pure as possible, and mixed with sodium chloride, to the well-known process of roasting.

The zinc chloride thus formed, which is volatile at 710° C. is collected by sublimation. It is freed from iron by passing it over zinc oxide:



The other contained metals and metalloids are eliminated by remelting the sublimed chloride in a bath of metallic zinc. It is evident that it is desirable to work only with rich blends, to reduce to a minimum the intervention of the metallic zinc treatment.

The aluminium chloride is prepared by the classic method of Sainte-Claire-Deville, but with the substitution of bauxite for pure alumina. The bauxite, mixed with 25 per cent of its weight of anthracite coal, is pulverized, then agglomerated with addition of 10 per cent of tar, into oval balls or briquettes. These briquettes are calcined, and then treated with chlorine, in a suitable chlorination apparatus, such as a vertical retort.

The gaseous products of the reaction pass into a condenser, where the aluminium chloride, mixed with ferric chloride, is separated. The permanent gases, and the silicon chloride, pass into a chamber suitably removed from the first chamber, and into which is injected a thin stream of water vapor, which decomposes the silicon chloride into silica precipitated upon the walls of the chamber, and hydrochloric acid, which is gathered with the free chlorine into an absorber containing roasted blende, moistened with water. Zinc chloride is here formed separated by lixiviation, concentrated by means of the waste heat from the chlorination apparatus, and finally added to the blende intended for the chlorination roasting. In this way it is said there is recovered a certain proportion of zinc chloride, which re-enters into the operations.

When a sufficient quantity of impure aluminium chloride has been sublimed, communication is interrupted with the sublimation chamber, as well as with the chlorination retort of which latter the gaseous products are directed into a relay condenser. The sublimation chamber being thus isolated, the liquid zinc is introduced, the chamber hermetically closed and heated gently so as to liquefy the aluminium chloride under its proper vapor pressure. The zinc reduces any ferric chloride present, and sets free the iron. The sublimation chamber is then connected to the reduction apparatus.

In this operation only aluminium chloride is disengaged, the zinc chloride remaining in the chamber, which is now heated to a temperature under 500° C. The aluminium chloride vapors coming into contact with the zinc-sodium alloy are reduced, and there is formed, as has been described, the double chloride of aluminium and sodium, and metallic aluminium, containing, however, several per cent of zinc.

This zinciferous aluminium is now poured into the channel or canal which forms the crucible of M. Gin's electric incandescent furnace, which consists of a canal of relatively great length and small cross-section, doubled several times upon itself, upon a hearth of refractory material. (See ELECTROCHEMICAL INDUSTRY, January, 1904). The extremities of the canal are connected with blocks of aluminium of large section which serve as connections to the electric current.

A canal of 16 cm. metallic section, containing about 100 kilogs. of aluminium, is said to be purified in several minutes by a current of 10,000 amperes, at 25 volts. The volatilized zinc is collected in metallic receptacles fixed in the walls of the furnace, while the aluminium is cast into ingots. The chloride

of zinc and sodium is recovered and returned to the electrolytic apparatus for chlorine and zinc-sodium.

M. Gin claims "the process of manufacturing aluminium, consisting in the reduction of aluminium chloride by zinc-sodium alloy ZnNa_2 (about 40 per cent sodium); said process being characterized by the direct attack upon bauxite by chlorine, which chlorine is obtained by electrolysis of the double chloride of sodium and zinc, and of zinc, which furnish simultaneously the reducing alloy; the electrolyte $\text{ZnCl}_2 \cdot 2\text{NaCl}$ being reconstituted by the same reduction, in such fashion that the various operations form a closed cycle with regeneration of intermediary products."

It is, of course, obvious that this process involves considerable manipulation, and much carefully balanced chemical treatment. It will be interesting to learn more about such a process if it should be tried upon a commercial scale.

PREPARATION AND COMPRESSION OF PURE GASES FOR EXPERIMENTAL WORK.*

By R. S. HUTTON AND J. E. PETAVEL.

Having been engaged for some time past on experimental research dealing with the effect of high gaseous pressure upon electric furnace reactions, the necessity arose of preparing, compressing, and storing several gases which were either not available commercially, or which could not thus be obtained in the desired state of purity. Although a very great deal of information had been published relating to the production of the various gases in sufficient quantities for ordinary laboratory experiments, such methods cannot be easily applied when the required scale of working is considerably larger. On the other hand, the commercial manufacture in some cases has been most carefully worked out, but the plant required is too large and costly to be practical for temporary use.

The object of the present paper is to describe how, with little more than such apparatus as should be available in any chemical laboratory, the preparation of a number of gases can be carried out at a trifling cost, and with due consideration as to their purity. It will be noticed that the equipment is so devised as to be available for use in the different cases with but little modification. Those who look for any novelty in the principles of the methods adopted will, we fear, be disappointed; we venture, however, to think that to the increasing number of workers, who, either for commercial or scientific purposes require, like ourselves, pure gases in considerable quantities, the information which we offer will be of some value.

The apparatus has been devised for gas generation and purification at a rate of about 1 liter per second (130 cubic feet per hour). Hydrogen, nitrogen, carbon monoxide, and ethylene are dealt with in detail. Apart from the information which we have been able to obtain by direct experiment, references are given to several of the more important published accounts dealing with the manufacture on the full commercial scale. For some chemical purposes, the gases would be passed straight from the generator for use in the chemical process for which they were required; on the other hand, it is frequently necessary for convenience to store the gas for subsequent use; in fact, where the experiments are at all general in character, it is advisable to have a stock of different gases constantly available. This involves the erection of compressing and storing plant, even where high pressure *per se* does not play a part in the work. Our account, therefore, includes a description of a small plant which we have found satisfactory for these purposes.

HYDROGEN, ITS COMMERCIAL MANUFACTURE AND APPLICATIONS.

Hydrogen is at present principally employed for inflating military balloons, autogenous welding, and lead-burning

*A paper read before the Manchester Section of the Society of Chemical Industry.

(*Zeitschr. f. Elektrochemie*, 1895, vol. 2, p. 204), and is manufactured in considerable quantities for these purposes. The older and purely chemical methods of generation based on the action of acids or steam on metals are being to a large extent displaced, where a continuous supply is required, by electrolytic processes, the working cost of the latter being considerably lower. Suitable electrolytic cells can now be installed at a reasonable expense.

The plant for the chemical manufacture by the action of acids on metals is of two principal types. The first is a development of the ordinary laboratory "Kipp," and will be described later. The second type is designed to give for a limited time a very large quantity of gas, and in principle consists in employing a tall cylindrical receiver filled with metal turnings or granulated metal, the outflow of gas being regulated by the amount of acid which is allowed to flow into the top of the cylinder, the spent acid being run off at the bottom. This latter method is of the two, by far the more important for large scale working, such as for inflating balloons. In this case some 10,000 cubic feet of gas may be required to fill a single balloon, an operation which has to be effected within a short space of time. The process has also been employed for many years at the Royal Institution for the manufacture of hydrogen in connection with the liquefaction experiments, and at a more recent date by Morris W. Travers, at University College, London (*Phil. Mag.*, 1901 [6], L, 411).

A plant on these lines has been recently constructed by Messrs. Lennox, Benton and Reynolds, Ltd., capable of de-

alt with in any quantity.* Moreover, the gas generated by the action of acids on ordinary spelter or metallic iron is liable to be considerably more dense than pure hydrogen. (W. Dürer, *Zeitschr. f. Elektrochemie*, 1901, vol. 8, p. 2.) Of other chemical processes, the heating of zinc-dust and soda-lime briquettes is employed in the German army in a portable equipment for balloon inflation, while the reaction between heated iron and steam has recently been applied by the Industrial Engineering Co., who regenerate the iron with producer gas, and have thus brought this method into a convenient and practical form.

The electrolytic manufacture of hydrogen is coming much to the front; in this case, whereas the first cost is relatively high, the working expenses, whenever the plant can be run continuously, are generally lower than for the chemical method. Numerous types of plant have been designed, the principal requirements being a low working voltage and the effectual separation of the hydrogen and oxygen; the latter, particularly where the gases have to be compressed, being of the utmost importance from the point of view of safety. The electrolytic methods will be found described in monographs by Victor Engelhardt and P. Schoop [*V. Engelhardt, Die Elektrolyse des Wassers* (Halle: W. Knapp, 1902); P. Schoop, *Die Industrielle Elektrolyse des Wassers* (Stuttgart: F. Enke, 1901)]; suffice it to say that in principle they can be grouped under three types:

(1) The Schmidt and Ch. Renard systems employ iron electrodes in alkaline solution, the electrodes being separated by diaphragms of asbestos.

(2) The Schoop system, in which each cylindrical electrode is surrounded by tubular diaphragms, has the advantage of absolute safety from any danger of admixture of the gases, but involves some loss of power through additional resistance. In this case lead electrodes are employed in an acid electrolyte.

(3) The Garuti, Siemens Bros., and Schuckert plants employ metallic diaphragms and generally work with alkaline electrolytes.

At the present time almost all the European military authorities have adopted one or another of these electrolytic plants for balloon purposes, but in Germany the government makes use largely of the waste hydrogen evolved in the electrolytic alkali industry, an example which will, no doubt, be widely followed in the future, when it is considered that, even at a moderate estimate, some 240,000 cubic feet of hydrogen are going to waste daily in this way (*cf. Zeit. f. Elektrochem.*, 1895, vol. 2, p. 290). At least three large installations (*Buffa, Bull. de l'Assoc. des Ing. Electr.* (Liège), 1900, vol. 11, p. 305), those at Brussels, Lucerne and Rome, exist on the continent for putting on the market compressed hydrogen obtained by the Garuti process, a notable economy resulting from the fact that the oxygen, which is also compressed, finds a still more ready sale.

A complete consideration of the question of cost would carry us too far, but full details will be found in the monographs referred to. Suffice it to say that, with spelter at £21, (about \$102) a ton, a cost of at least some 35s. (about \$8.40) is incurred in zinc alone per 1,000 cubic feet of hydrogen obtained, whereas by several of the electrolytic processes the same amount of hydrogen can be obtained for 157 kilowatt hours, which, even at 1d (2 cents) per unit, a high estimate for power generation when used continuously, only amounts to 1.3s. 1d. (about \$3.14). It should be borne in mind that the oxygen produced simultaneously is also of considerable commercial value.

Thus, where an uninterrupted supply of gas is required

*Numerous attempts have been made to remove the arsenic from the gas, amongst which passage through a heated tube or a solution of a permanganate should be mentioned. Recently Ch. Renard has carried out some experiments on the use of liquid air for condensing the arseniuretted hydrogen in connection with the aeronautical department of the French army. It is found that cooling to 110 degs. C. is essential for complete elimination of the arsenic. (*C. R.*, 1903, v. 136, p. 1317.)

- A. Acid reservoir.
- B. Cooling tank.
- D. Generator proper.
- C and E. Washing towers.
- b. Valve regulating admission of acid.
- g. Sight feed for ditto.
- K. Outlet for gas.
- c and d. Valves regulating water admission to washing towers.
- e and f. Sight feed for ditto.
- H. Cast-iron tank acting as seal to the cylinders, and into which spent acid flows.
- K. Outlet for gas.

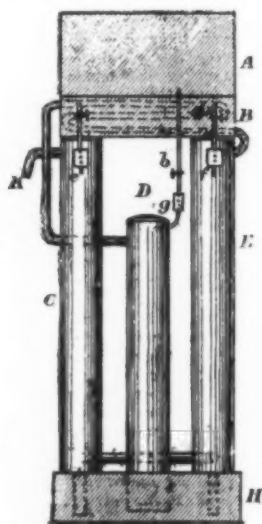


FIG. 1.—HYDROGEN GENERATOR PLANT.

(Scale, $\frac{1}{2}$ inch to foot.)

livering some 800 cubic feet of hydrogen per hour. The receiver is a copper cylinder about 6 feet high and 1 foot diameter, and contains a charge of 4 cwts. of granulated zinc. As will be seen by the diagram, Fig. 1, the actual generator is mounted in the center between two washing towers, each 8 feet high. The three cylindrical towers, which are open at the bottom, are supported in a cast-iron tank, which forms a water seal and collects the spent acid. The towers are surmounted by two superimposed tanks, the lower one containing a lead coil immersed in water to act as cooling chamber, the upper one, lead-lined, acting as acid reservoir. A spray of water keeps the flints in the two washing towers moist. The rate of flow of the acid is observed through a sight feed.

An apparatus of a similar type, the design of Ch. Renard, has been adopted by the French army for field use. The employment of zinc has, however, the serious disadvantage that the gas often contains sufficient arsenic to be dangerous if

throughout the entire year the electrolytic methods offer considerable advantages. Owing, however, to the much smaller capital outlay, the older chemical process is preferable when the hydrogen is required occasionally only, but in large quantities. Several years ago Dewar showed, as a lecture experiment, how coal-gas could be freed from methane and other hydrocarbons by cooling it to a sufficiently low temperature. Recently d'Arsonval (*Ann. Chim. et Phys.*, 1902 [7], vol. 26, p. 446) has proposed this as a method of obtaining hydrogen; the process has, however, not yet proved of any commercial value.

Experimental Plant.—In considering the type of apparatus suitable for experimental work, it must be borne in mind that the plant should be capable of producing gas at a comparatively high rate, at least for a limited number of hours. As will be more fully explained in describing the compressing plant, it is advisable to make the gas in sufficient quantities to supply the pump at its normal rate of working, which in our case was 100 to 130 cubic feet per hour. Under all conditions where the cost of a large capacity gasometer is not prohibitive, it would doubtless be more convenient to generate the gas slowly and continuously and then compress it, whenever the gasometer was filled. With such an arrangement it would have been more convenient even in the laboratory to use the electrolytic process.

Preliminary experiments made in this direction showed that a satisfactory electrolytic cell could be easily and cheaply fitted up. This was effected by lining the sides of an ordinary stoneware mix-pan with sheet lead, and using as a cathode a spiral coil of lead tube, covered with an inverted bell jar. From the top of this the gas is drawn off. To equip a plant to make gas at the rate mentioned above was, how-

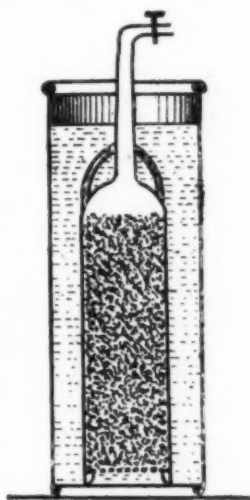


FIG. 2.—EXPERIMENTAL HYDROGEN GENERATOR, CONSTRUCTED THROUGHOUT OF LEAD. HEIGHT, 2 FT. 6 INS.; DIAMETER, 1 FT.

ever, too costly for a temporary outfit. The preparation from Brunner-Mond zinc and 20 per cent arsenic-free sulphuric acid was therefore resorted to, spelter of this quality being found to give gas of high purity. Sufficiently finely granulated zinc can be obtained by pouring molten metal into water from a height of about 3 feet. Three lead generators were used, of the ordinary type containing solid caustic soda, direct to the gasometer and compressor. Analysis proved the purity to be 98. per cent hydrogen.

NITROGEN: COMMERCIAL MANUFACTURE AND APPLICATIONS.

Already at the present time nitrogen is coming into use in several of the cyanide processes, an application which will doubtless increase largely so soon as a satisfactory and economical method of generation has been devised. For, despite the apparent simplicity of the process, no very economical method of effecting the separation from the oxygen of the air is available. The older method of passing air over heated iron or copper is chiefly employed technically. In those cases where a large supply of nitrogen is needed, it would be advisable to carefully consider the employment of the waste gases from gas engines and sulphuric acid plants, which are available in quantity and contain a much reduced percentage of oxygen. It must also be borne in mind that similar gases are passed to waste in the course of manufacture of oxygen by Brin's process; whilst, provided any of the proposed methods of extraction of oxygen from liquid air by fractional distillation become of permanent commercial value, they will prove of direct assistance for the problem under consideration.

As will be seen below, pure nitrogen can be prepared at moderate cost by an adaptation of the Harcourt method (Lupton, *Chem. News*, 1876, vol. 33, p. 90; R. Marston, Eng. Pat. 19,074 of 1900), consisting in burning out the oxygen of the air by the hydrogen contained in ammonia. Finally, the laboratory process of generation from ammonium nitrite (K. T. Fischer and H. Alt, *Ann. der Phys.*, 1902 [4], vol. 9, p. 1149; von Knorre, *Chem. Ind.*, 1902, vol. 25, p. 531 and p. 550) is out of question for large scale working, owing to the prohibitive cost of material. At the recent International Chemical Congress, R. Knietzsch (*Chem.-Zeit.*, 1903 [48], p. 586) proposed passing air and excess of hydrogen over warmed platinized asbestos; and at the same meeting a few details were given of

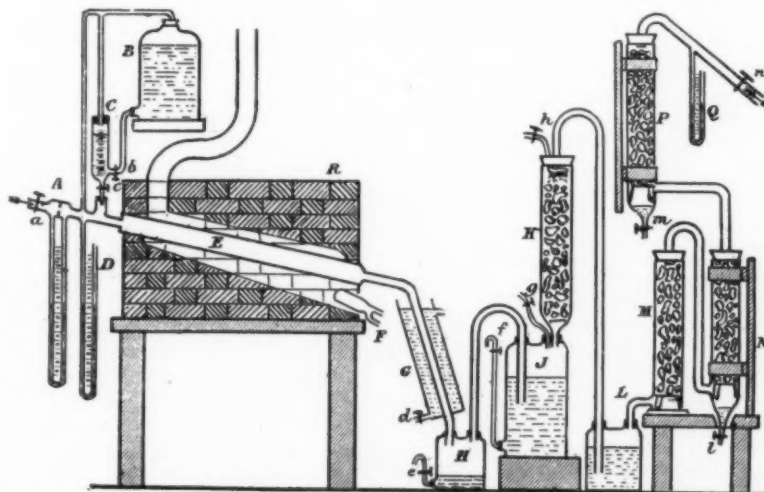


FIG. 3.—DIAGRAM OF NITROGEN PLANT.

a. Air-inlet tap from blower.
A. Gauge indicating rate of flow of air.
B. Reservoir of ammonia liquor.
C. Graduated tube for measuring rate of flow of ammonia.
d. Tap for filling tube C with ammonia.

c. Tap for regulating admission of ammonia.
E. Iron gas-pipe filled with copper turnings.
R. Furnace; built up of loose firebricks, and heated with large Fletcher furnace tuyere F.

G. Condenser with water inlet cock d.
H. Condensed ammonia receiver with draw-off c.
J. Water washer, through which water or acid could be passed, inlet cocks at g or h, outlet at f.
L. Acid washer.

M. Quartz tower scrubber.
N and P. Two caustic soda towers with draw-off cocks at m and l.
Q. Manometer.
S. Exit to gasometer and compressor.

the process of Messrs. Elkan, of Berlin, who supply the compressed gas in cylinders.

Experimental Plant.—From preliminary trials the Harcourt method seemed to be the only one which could be fitted up in a limited space with ordinary apparatus and suitable to produce gas at a moderate cost. The plant is shown in Fig. 3. An iron gas-pipe about 5 feet long and 2 inches internal diameter was filled with copper turnings, connections being made at one end for the introduction of air, supplied by a blower, and of the required quantity of ammonia liquor; at the other end to condensing, washing, and drying plant, and through these to the compressor. The method works without the slightest difficulty, provided that the rate of admission of air and ammonia is properly regulated. From the preliminary experiments it was found that unless the ammonia is always in considerable excess of that required theoretically, oxides of nitrogen are produced which cannot easily be removed. When gas containing such impurities is compressed, serious corrosion of the valves and cylinders of the pump occurs. On the other hand, if the excess of ammonia is not removed, similar difficulties are met with.

The method of working actually adopted was to admit approximately twice the theoretical amount of ammonia, and by passing a fairly rapid current of water through the washer J, such part of the ammonia as was not condensed in H was efficiently removed, the last traces of ammonia being held back by the sulphuric acid in L. To regulate the quantity of ammonia necessary, a rate gauge A was inserted in the air-supply pipe. This gauge was of a very simple construction, and consisted of a constriction in the supply tube each side of the construction being connected to one limb of a U-tube containing water, the difference in heights of which indicated the rate of flow of the gas. The instrument is calibrated, once for all, by taking observations with an ordinary gas meter or gasometer. The scale of the readings depends, of course, simply on the size of the constriction.

As an example, one of these gauges, having a constriction of about $\frac{1}{8}$ -inch bore, gave about 40 cms. difference of level for a rate of 60 cubic feet per hour. Knowing in this way the rate of flow of the air, the admission of ammonia liquor was regulated by means of the graduated tube, so as to supply about twice the theoretical amount. The method by which this was performed will be quite clear from the diagram. The gas obtained was entirely free from oxygen and oxides of nitrogen, but contained about 4 per cent hydrogen. This could, of course, be easily eliminated by passing through an additional tube of heated copper oxide, but for most purposes the presence of hydrogen would be of no disadvantage.

For the guidance of any one employing the method in this form, we might state that in one operation some 200 cubic feet were compressed, about 9 liters of 0.880 ammonia being passed through the apparatus; the flow of gas was regulated from time to time so as to supply the pump continuously at its normal rate of working. The cost of the ammonia for 1000 cubic feet of nitrogen would be about 17s. 6d. (about \$4.20), or half this amount if the excess of ammonia is efficiently recovered.

CARBON MONOXIDE.

Experimental Plant.—For most chemical processes pure carbon monoxide is rarely required, some form of producer or water-gas being generally employed. Where, however, the pure gas is a necessity, the manufacture of formates by the recent synthetical Goldschmidt process renders it possible to obtain it at a reasonable cost and in an extremely simple manner. The actual apparatus used is shown in diagram (Fig. 4), and consists of a bolt-head E (9 liters) half filled with sulphuric acid (sp. gr. 1.73). The heating was performed either by an electric resistance furnace as represented, or by an ordinary gas furnace; the former is preferable, when working with combustible gases, where electric current is available.

An electric furnace of the kind can be built up temporarily

at trifling cost. The outer walls are constructed of loose fire-bricks; the electrodes consist of two flat pieces of boiler plate, the space between which is filled with ground coke. An electric current passing through the coke heats this up to any desired temperature. In the present case the iron plates were each 11 inches square, the distance between them being 14 inches; the layer of coke G, about 40 pounds, being 7 inches deep. This gave a resistance when cold of 13 ohms and about 1.5 ohms when heated up to the working temperature. When generating gas at full rate, over 4 kw. are required to maintain the temperature.

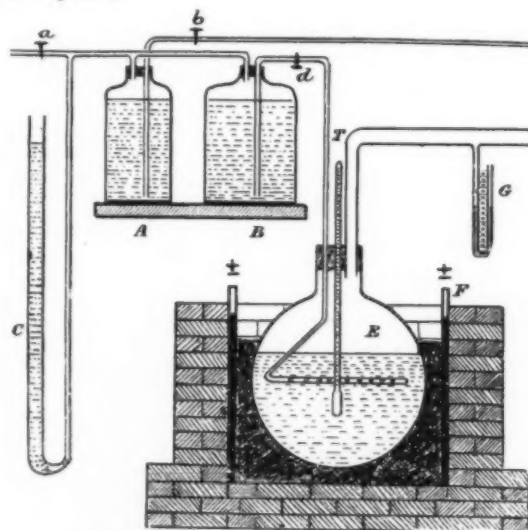


FIG. 4.—DIAGRAM OF CARBON MONOXIDE PLANT.

- E. Bolt head containing boiling H_2SO_4 .
- T. Thermometer.
- F. Reservoir for formic acid.
- G. Gauge on main gas-pipe before washing apparatus.
- F. Electric heating furnace.
- a. Inlet cock from compressed air.
- C. Tube acting as constant pressure valve, keeping a pressure equal to 2 or 3 ft. of water on upper surface of liquids in flasks A and B.
- A. Reservoir of caustic soda solution connected with washing tower K (Fig. 3).
- b. Regulating cock for same.

The reservoir B contains a supply of technical 90 per cent formic acid, from which the carbon monoxide is generated. This reservoir is kept slightly above atmospheric pressure by being connected to a supply of compressed air, thus enabling the acid to be easily forced over. The former acid is delivered below the surface of the boiling sulphuric acid in the bolt-head, the flow being regulated by the cock *d*. The temperature which, when the formic acid is added, of course tends to fall, is maintained throughout the run at about 150° to 170° C. In this way, with a limited amount of sulphuric acid, the process can be run continuously.

The gas is purified in the apparatus shown in Fig. 3, the only modification being that the bottle L is in this case filled with 20 per cent caustic soda solution, and a similar solution is also allowed to drip into the quartz tower K (Fig. 3) from the supply bottle H (Fig. 4). Nearly the full theoretical yield of gas is obtained, about 133 pounds of 90 per cent formic acid being required per 1000 cubic feet, costing 50s. (about \$12). The purity of the gas thus prepared was over 99 per cent.

ETHYLENE.

Experimental Plant.—Up to recent years ethylene has been used in considerable quantities in connection with the production of liquid air; the apparatus which we have already described for carbon monoxide can, without modification, be employed for this preparation. There is not, however, the same latitude with regard to temperature and rate of production as in the former case. It is essential that the sulphuric acid should be kept between 160° and 165° C., since, even at a few degrees above this, carbonization commences, accompanied by produc-

tion of sulphurous acid and carbon monoxide; at a temperature below 160°C ., the yield falls very rapidly, almost all the alcohol being transformed into ether. The sulphuric acid used in the bolt-head should be of such dilution as to boil at 160°C . Methylated spirit admitted through a perforated lead tube (see Fig. 4). At first scarcely any ethylene is evolved, but as part of the water in the acid becomes displaced by the alcohol, the temperature being kept constant, the rate of production gradually increases, and, after about half an hour, becomes fairly steady.

A constant evolution of gas can be maintained under these conditions for any length of time, but the flow of gas is only about one-tenth of what the same sized apparatus would produce in the case of carbon monoxide. The yield obtained was not much more than half the theoretical. An addition of ferrous sulphate to the sulphuric acid has been proposed by R. N. Lennox as ensuring against carbonisation and evolution of sulphurous acid. This addition seems to be a considerable improvement on the original process. The acid mixture is made with concentrated sulphuric acid (sp. gr. 1.84) and sufficient saturated ferrous sulphate solution to bring the boiling point down to 160°C .

Another method proposed by G. T. Newth (*Jour. Chem. Soc.*, 1901, v. 79, p. 915), which consists in employing syrupy phosphoric acid in place of sulphuric acid, was tried in the same apparatus. The temperature should be kept between 200° and 220°C .; there is no carbonization, but a considerable amount of ether is collected. The yield in this case was even lower than with the sulphuric acid method, but the process can be worked quite continuously, and the quantity of phosphoric acid required is not large.

VARIOUS OTHER GASES.

The foregoing notes deal with the preparation of such gases as cannot easily be obtained commercially. With regard to many other gases similar methods could, of course, be adopted, but producing them on the scale with which we have been dealing would hardly repay the trouble involved, in those cases where they are already on the market. Further, for such gases as sulphuric acid, chlorine and ammonia, a special pump would be necessary; and even before oxygen could be compressed, much time would have to be spent in carefully removing all traces of organic matter from the pump cylinders, connections and gauges.

Oxygen, nitrous oxide, carbonic acid, sulphurous acid ammonia can readily be obtained from the various companies who make a specialty of their manufacture. Where a compressed gas is not required, oxygen in a similar way to acetylene can be produced by the action of water on one of its solid compounds. A French company has recently put on the market a mixture of sodium peroxide and bleaching powder, under the name of "Oxylith," which yields oxygen of satisfactory purity. The cost of the gas produced by this method (5s. 9d., or about \$1.38 per 20 cubic feet) would, however, be prohibitive where a large quantity is required.

So far as acetylene is concerned, it will be recalled that, as a result of the exhaustive investigations which followed on numerous and disastrous accidents, Bethelot and Vielle showed that it is highly dangerous to compress this gas above four atmospheres. The gas, however, can now be stored in cylinders, filled with some porous material saturated with acetone, this liquid absorbing about 24 times its own volume of gas per atmosphere pressure (A. Janet, *Génie Civil*, 1903, 180).

In Germany (O. N. Witt, *Die Chemische Industrie des deutschen Reiches im Beginne des 20 Jahrhunderts*, pp. 100-105) considerable use has been made in recent years of liquid chlorine, which is produced by several companies, and notably by the Badische Anilin Company, and can be obtained retail (e. g., Kahlbaum, Berlin) for 1s. 6d. (36 cents) per pound in bombs of 20 pounds or over. Methyl chloride (2s., or 48

cents per pound, Douane, Paris), phosgene (Kahlbaum, 6s., or \$1.44 per pound), and ethyl chloride (2s., or 48 cents per pound), can all be obtained commercially, and find uses, particularly in the color industries and for refrigeration.

COMPRESSION AND STORAGE OF GASES.

The portion of the subject which we have to deal with now is of rather a special nature. Much of the information given below will be well known to those few who have been connected with commercial gas-compression plants; but now that pumps can be obtained at a moderate cost and of sufficiently simple construction to give no trouble for continuous working, there is no reason why the great convenience of storing gas in the compressed state should not be more generally made use of. For work of this kind the smallest convenient plant comprises:

(1) A compressor capable of dealing with 60 to 130 cubic feet per hour, and of working up to 120 or 200 atmospheres.

(2) A small gas-holder (10 to 20 cubic feet capacity), which is used, not to store the gas, but to act as an equalizer between the pump and generating apparatus. It being assumed that, wherever possible the gas is made and pumped at the same rate.

(3) A stock of weldless steel gas cylinders.

As a general guidance with regard to cost, the price of the compressor may range from 60 l. to 100 l., (about \$290 to \$485) and the gasometer from 10 l. to 20 l. (about \$48.50 to \$97). For most purposes it is convenient not to exceed the commercial pressure of 120 atmospheres. For this pressure, gas cylinders, ready fitted with valves, can be obtained at about 1s. (about 24 cents) per cubic foot of gas stored, when purchased in small quantities; or at half this price when bought on a larger scale. For higher pressures, the cylinders have to be made to order, and are correspondingly more expensive. Another 10 l. to 20 l. (\$48.50 to \$97) should be allowed for the purchase of two or three pressure-gauges, a dozen cone-connections, eight or ten high-pressure valves, and the capillary copper tubing which serves to conduct the gas from the compressor into the receivers.

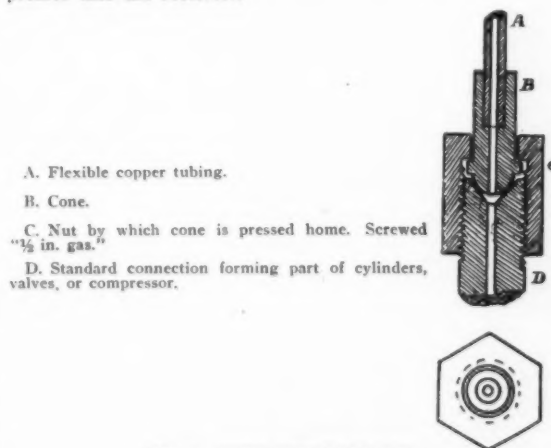


FIG. 5.—CONE CONNECTIONS.

Weldless copper tubing of $\frac{1}{8}$ inch bore and $\frac{1}{4}$ inch external diameter is both strong and large enough for this purpose, and can be readily obtained from any copper tube manufacturers. This size has the further advantage, when annealed, of being quite flexible, and can thus be bent, whenever used, to the most convenient shape. The ends of each length of such tubing are soldered into brass or gunmetal cones, as shown in Fig. 5. These are screwed to the cylinder or pump valves by a nut which surrounds them. In a plant of this kind it is advisable to keep to a standard size, "half-inch gas" being most convenient for this purpose.

An ordinary air-pump is, of course, not suitable for dealing with combustible gases. The cylinders of the compressor should be entirely closed, the piston-rods passing through properly made stuffing boxes. The smaller compressors are usually of the tandem two-stage type, the low-pressure cylinder compressing to about 7 atmospheres, the gas being then passed through a cooling coil into the high-pressure cylinder, which forces it up to the full pressure. The high-pressure cylinder delivers its gas, through another copper coil immersed in a cooling tank, into a small gas cylinder, which serves to separate the water used to lubricate the pump. At the bottom of this separator is a valve for withdrawing the water.

If the pump is required to suck in its supply of gas under a partial vacuum, the low-pressure inlet valve should be arranged so as to be mechanically lifted at the top of each stroke. The water for lubricating the cylinders is fed through a sight feed, and for a compressor of the size we are dealing with, a single drop per two or three revolutions is an ample supply. The clearances should, in both cylinders, be about 1-32 inch, or at any rate not exceed 1-16 inch, in order that, at the highest working pressures, the pump may deliver its full volume and not merely compress and expand the same gas.

The following precautions are of the highest importance from the point of view of safe and satisfactory performance:

(1) The greatest care must be taken never to allow much more than the above-mentioned quantity of lubricating water to enter, as with such small clearances this water carried into the high-pressure cylinder would be unable to pass through the narrow outlet valve and would burst the cover or bend the crank-shaft.

(2) If the apparatus is to be used for air, or more especially for oxygen, it is of vital importance that no oil should be employed, either in the pump cylinders or in any of the valves, connections, or gauges. Many disastrous explosions have resulted from the neglect of these precautions. The water, may, however, if desired, be replaced for lubrication by glycerine, which forms an excellent substitute for oil for this purpose.

(3) Each time before running the pump, it is advisable to turn it through one or two revolutions by hand to ensure that it is working freely. If the gas to be pumped is combustible, before connecting to the gas holder the pump should be run for a minute or two, with the inlet cock closed, and the end of the delivery pipe placed under water. In this case, if the stuffing boxes and connections are satisfactorily tight, the pump will be running under a vacuum and should deliver absolutely no gas.

(4) The purity of any combustible gas must, of course, be properly ascertained, as any admixture with air would lead to serious explosions.

(5) It is very advisable to adopt the excellent system, employed by all the gas-compressing companies, of distinguishing between combustible and non-combustible gases, by invariably storing the former in cylinders characterized by a bright red color, and fitted with left-handed connections. Even where this is done it is advisable before connecting a partially filled cylinder with the pump to test its contents at a flame.

(6) All storage cylinders, connections, and other apparatus, with the exception of gauges should be occasionally tested hydraulically to double the maximum working pressure.

So far as the actual compressing is concerned, a clear idea will be obtained from the diagrammatic sketch (Fig. 6). The gas passes from the purifying apparatus shown in Fig. 3 to the gasometer A (Fig. 6), from which the two-stage compressor, driven by an electric motor, forces it into the water separator F. At its exit from this separator the gas is sufficiently dry for almost any purpose for which it may be required, since the percentage of aqueous vapor in a gas at 100 atmospheres is only 1-100 of its amount at ordinary pressure. When the gas is being made at the normal rate the valve *k* is kept open, the valve *m* closed, and the gas passed directly into a storage cyl-

inder, such as L or K, or, in the case of our own work, direct into the pressure furnace M. These were situated in the room on the next floor of the building to the compressor.

A high pressure connection is also led direct to a duplicate gauge *g*₄, by which the pump pressure can be independently read. When necessary the gas can be blown off from the valves *q* on the upper floor, or *o* on the lower; *o* being connected to a pipe leading outside the building, for use with poisonous gases such as carbon monoxide. If, for any reason, the supply of gas falls below the normal rate, the valves *m* and *l* are partially opened, *n* being kept closed; a part of the gas delivered by the pump then returns to the gasometer, and is compressed again, thus avoiding the necessity of either stopping the pump or working it under a partial vacuum.

When dealing with gases which can only be conveniently prepared at a very slow rate, it is, of course, necessary to give up any idea of continuous pumping. In these cases the gasometer is allowed to fill slowly; the pump is then started, and stopped a few minutes afterwards, so soon as all the gas has been pumped. The storage cylinder is thus filled step by step up to a desired pressure. It is not possible to restart the pump against a high pressure; the gas contained in the water separator F must therefore be blown off, and since, at a high pressure, the volume thus returned to so small a gasometer would take up a large part of its capacity, it is preferable to employ an auxiliary cylinder G, which takes the major part of the contents of F, the residue only being returned to the gasometer by the valves *k*, *m* and *l*. The contents of G can be returned to the gasometer and pumped during the course of the next run through the valves *n* and *l*, *m* being kept closed. This last method of working is, of course, somewhat complicated, but has proved very useful in a few cases where it was practically impossible to produce the gas at the normal rate.

For those purposes where it is required to study some chemical reaction or to purify a gas when under high pressure, a gas cylinder with a removable cover is employed. The ordi-

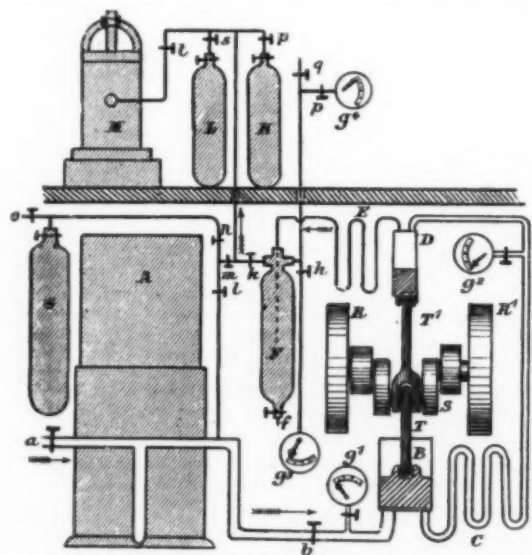


FIG. 6.—DIAGRAM OF COMPRESSING PLANT, GASOMETER, AND CONNECTIONS.

a. Inlet cock to gasometer from gas generating and purifying apparatus (see Fig. 3).
A. Gasometer (10 cb. ft. capacity).
b. Inlet cock to compressor.
g₁. Vacuum gauge on inlet to low-pressure cylinder.
B. Low-pressure cylinder.
C. Cooling coil for ditto.
g₂. Gauge showing pressure at exit from low-pressure cylinder.
D. High-pressure cylinder.
E. Cooling coil for ditto.
F. Water separator.

f. Water blow-off.
G. Gas cylinder used as auxiliary receiver.
g₃. Gauge on high-pressure outlet.
g₄. Duplicate high-pressure gauge.
K, L, M. Receivers for compressed gas.
q, o. Blow-off valves.
R, R'. Pump fly-wheels.
S. Crank shaft.
T, T'. Connecting and piston rods.

nary cone joint, as shown in Fig. 5, works satisfactorily to close the opening of any tube up to one-inch bore. Above this size it is necessary to resort to some form of spigot joint, such as is shown in Fig. 7. One or two turns of lead wire about the same diameter as the groove, are inserted in it, the ends of the lead being beveled so as to overlap each other. The cover is then forced home by means of the bolts provided for the purpose, and, crushing the lead outwards and upwards, forms a gas-tight joint.

A. Cylinder containing solid reagent to dry or purify a gas under pressure, or react with it.

B. Cover.

D and D'. Bolts.

E. Spigot and spigot groove (about $\frac{1}{4}$ inch wide for 2-in. bore, rising to $\frac{1}{4}$ or $\frac{1}{2}$ -16 in. for sizes up to 1 ft.)

The central part of the cover projects beyond the spigot, and is turned to nearly fit the bore of the cylinder. This acts as guide when putting on the cover, and protects the spigot itself from injury when the lid is off.

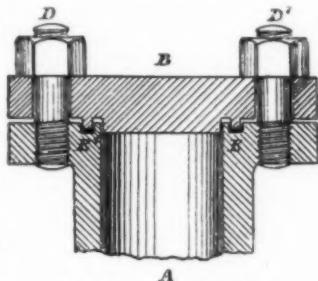


FIG. 7.—SPIGOT JOINT.

When making such a joint for the first time, exceptional care must be taken that the nuts are pulled down evenly, as otherwise the cover may be strained or, being out of true, the joint will not be gas-tight. When the cover has once been fitted correctly it can be removed and replaced some hundred times before it is necessary to add fresh lead packing. We have used joints of this kind up to a foot diameter, which have always worked satisfactorily. Above this diameter the weight of the cover and the size of bolts required become somewhat unmanageable when designed for pressures of 100 to 200 atmospheres.

In the discussion which followed the reading of this paper, and which is given in full in the *Journal of the Society of Chemical Industry*, February 15, p. 93, Mr. W. Thomson thought that the authors had not dealt sufficiently on the merits of the process, worked by the Industrial Engineering Company at Newton, near Hyde, as a comparatively large-scale laboratory method. It is one that may be easily carried out in the laboratory. Superheated steam is passed through iron turnings (heated to redness in a retort); the turnings become oxidized, liberating the hydrogen from the steam. Coal gas or producer gas can then be passed over the iron oxide, with a resulting deoxidation of the iron. Superheated steam is again passed over the reduced iron. He claimed that hydrogen could thus be obtained almost chemically pure at a cost of about 1s. (24 cents) per 1000 cubic feet.

In view of the large excess of ammonia, which the authors found necessary to use when producing nitrogen by means of Harcourt's process, it was suggested by Dr. Markel that this amount might be lessened if precautions are taken to eliminate the water vapor from the mixture of ammonia and air, entering the combustion tube.

Mr. Scudder had some years ago used steel cylinders for compressing water gas, and found that after a time the gas was contaminated with iron carbonyl, which rendered the compressed gas useless for illuminating and experimental purposes.

Mr. Hutton, in reply to Dr. Markel, said they had always employed double the required amount of ammonia in order to ensure against the presence of oxides of nitrogen; doubtless a smaller excess would be sufficient.

PRODUCER GAS AND WATER POWER

By OSKAR NAGEL, PH. D.

Dr. Joseph W. Richards, in his presidential address, delivered at the third general meeting of the American Electro-

chemical Society in New York City, April 18, 1903, called attention to the fact that there are sources of surplus power distributed over a large part of the United States in a condition at present as undeveloped as was Niagara Falls' power when Columbus came to these shores. Dr. Richards is thereby referring to the surplus power from blast furnaces and gas producers, obtainable by using gas engines.

There is no doubt that near coal mines producer gas power can be produced at about the power price of Niagara Falls, and by using blast furnace gas, power can be obtained even considerably cheaper, so that in the near future the blast furnace will be of the same importance as a gas producer as it is at present as iron producer.

A 20,000-hp. plant for blast furnace gas, completely erected, including building and gas purifying plant, will cost about one million one hundred thousand dollars (\$1,100,000) and the cost of a horse-power for 24 hours in such a plant will be $3\frac{1}{2}$ to 4 cents as compared with 5 cents for the lowest cost at Niagara Falls. This will enable the iron works also to sell power at a low price, and to make the blast furnaces great central power plants comparable to the water-power resources of nature.

For every ton of iron 45,000 cubic meters of gas are obtained, 50 per cent of which are used for heating the cowpers. There is, therefore, a surplus of 22,500 cubic meters for every ton of iron, corresponding to 7000 hp. hours.

The main point to be considered in estimating the cost of a producer gas power plant is the cost of coal, of which 1 to $1\frac{1}{2}$ pounds are required to develop 1 hp. hour.

Below are given the prices for power, figured on coal prices of 80 cents, 90 cents, \$1.00 and \$1.50 per net ton. They will show that it is only a matter of future development that the coal-mining districts will become great power stations of the world, and will be even more advantageous to certain industries than water power.

A 1000-hp. producer gas plant completely erected, including engine, will cost about \$66,000; figuring depreciation, interest and working expenses with coal price of 80 cents per ton, 1 hp. for 24 hours will cost, for such a plant, 5.19 cents. Figuring coal at 90 cents per ton 1 hp. for 24 hours will cost 5.37 cents. Figuring coal at \$1.00 per ton, 1 hp. for 24 hours will cost 5.55 cents, and figuring \$1.50 per ton for coal, 1 hp. for 24 hours will cost 6.45 cents.

These results compare favorably with the lowest price at Niagara Falls, that is, 5 cents per hp. in 24 hours.

Following are given the average price per short ton of coal in the United States for ten years:

	Anthracite.	Bituminous.
1892.....	\$1.57	\$0.99
1893.....	1.59	0.96
1894.....	1.51	0.90
1895.....	1.41	0.86
1896.....	1.50	0.83
1897.....	1.51	0.81
1898.....	1.41	0.80
1899.....	1.46	0.87
1900.....	1.47	1.04
1901.....	1.67	1.04

THE PRODUCTION OF PURE METALS FREE FROM CARBON BY THE ALUMINOTHERMIC METHOD.

By HANS GOLDSCHMIDT, PH.D.

In the issue of November, 1903, of *ELECTROCHEMICAL INDUSTRY*, a complete review of the manifold industrial applications of aluminothermics was given by the author. The following notes are intended to give some supplementary information on the production of pure metals by the aluminothermic method, and on the uses of such metals in metallurgy. As noticed in our former article, it was for the purpose of preparing

pure refractory metals, free from carbon, that the aluminothermic reaction was first made use of. While at first sight it might appear that no special extended practical development was required for a reaction of such apparent simplicity as the reduction of metallic oxides by aluminium, yet it is a fact that in the case of every metal much experimental work had to be done in order to obtain pure metals of uniform quality and with a high efficiency, so as to satisfy commercial requirements.

The aluminothermic preparation of the metals and alloys—especially chromium and manganese—as carried out now on a large commercial scale, takes place in a sort of crucible in which several hundred kilograms of metal are reduced in a single operation. On account of the great rapidity of reaction, this operation is completed in scarcely thirty minutes. The principle of the preparation of the mixture is, of course, to use equivalent quantities of the oxide and aluminium. In practice, however, the great facility with which aluminium alloys itself makes it advisable to use somewhat more of the oxide and less of the aluminium than would correspond to a mixture in equivalent proportions. The object is to oxidize all the aluminium during the reaction and to produce the metals free from aluminium. Solely by a suitable choice of the proportions of the mixture it is possible to regulate the reaction so as to get no aluminium in the reduced metal. This will surprise the experienced metallurgist in view of the great tendency of aluminium to alloy with the pure metals, and in view of the known fact that it is impossible to get metals free from carbon by means of reduction with carbon, even if a considerably larger amount of oxide is used than is equivalent to the carbon used for the reduction.

CHROMIUM.

Chromium, fused, free from carbon, with a purity of 98 to 99 per cent, can at present only be produced by the aluminothermic reaction. The metal, thus prepared, contains as impurities traces of iron and silicon. It is a brittle metal and remains bright indefinitely; its melting point is higher than that of platinum.

Pure chromium alloys with liquid steel. Its use allows the production of steels with a high content of chromium and with less carbon than is possible with the use of ferrochromium. The latter mostly contains carbon to the extent of 8 to 12 per cent of the chromium. The presence of this carbon makes it impossible to use ferrochromium for the production of steels with a high content of chromium and a comparatively low content of carbon. On the other hand, chromium free from carbon, as prepared by the aluminothermic method, is of great uniformity of composition. Faulty and unexpected fusions, which frequently occur in using ferrochromium on account of irregularities in the carbon content, will be avoided by employing pure chromium.

The addition of chromium to the charge in the Martin furnace can only be made at the end of the operation, and care must be taken to avoid the simultaneous introduction of injurious elements into the steel. Therefore, the less of the latter there are in the steel the better will be the quality of the steel. While with ferrochromium, even of a high grade, the loss through combustion reaches 20 to 25 per cent, the corresponding loss is much smaller if pure chromium is used.

Pure chromium is of the greatest practical value for the production of crucible steel. It is used for manufacturing guns, projectiles, and particularly for tool steels containing 5 to 10 per cent of chromium, 5 to 10 per cent tungsten, and not more than 0.6 to 0.7 per cent of carbon.

MANGANESE.

Manganese, made by the aluminothermic method, is free from carbon and practically free from iron. Its purity is about 99 per cent. It resists atmospheric influences for an unlimited period, while the manganese which is made in cru-

cibles by reduction with carbon, crumbles when in contact with air. Pure manganese is very brittle, and can be easily crushed with the hammer. In the fracture it often shows beautiful rainbow colors. One of its special features is the ease with which it alloys with copper, nickel, zinc, tin, aluminium and also with chromium, titanium and boron. The fusing point of manganese is considerably below that of chromium; by the careful investigations of Heraeus it has been found to be at 1245 deg. C. (2241 deg. F.)

Pure manganese is used for the manufacture of very hard steel which contains 12 to 14 per cent of manganese, especially for making steel bolts which are exposed to very heavy strain, for instance, in dredges, etc. It is, however, in the copper, brass and nickel industries that the great advantages of the use of pure manganese and its alloys are most apparent. Pure manganese may be added in any percentage to zinc-copper alloys, the result being a very essential increase of strength and density and often, also, of elasticity. Such alloys can also be rolled more easily.

Manganese should not be added to alloys of tin and copper, containing more than about 2 or 3 per cent of tin, as the quality of the material is thereby deteriorated. But if the content of tin is held within certain limits, manganese may be added to good advantage.

For nickel castings manganese is used as a de-oxidizing agent, to produce a greater density. In this case 2 per cent of manganese is added to the molten nickel. This is more advantageous than an addition of magnesium, for the reason that magnesium, if added in excess, has a bad effect; there is no such danger with manganese. In mints manganese is added to the copper-nickel alloys (25 to 75), from which the nickel coins are made; the addition of manganese amounts in this case to about 2 per cent.

Manganese is also used with good results for making German silver and nickel alloys; when added to the former in small amounts, a bright color is produced, similar to that of silver. For aluminium alloys an addition of manganese-copper, free from iron, is preferable to nickel or zinc additions. If the manganese-copper is added to the amount of 3 per cent, the strength of the material is increased, denser castings are obtained, and the alloy can be more easily machined; moreover, the cost is lower than an addition of nickel.

Copper and bronze castings lose their brittleness if manganese is added instead of phosphorus; a material is thus obtained in which threads may be easily cut. Manganese-copper alloys are made to a large extent, containing from 2 to 12 per cent of manganese. Bronzes with 5 to 6 per cent of manganese have about the same color as copper, and are very fire-resisting; they are, therefore, used especially in the fire-boxes of locomotives. Sometimes about ½ per cent of nickel is added to such a copper-manganese alloy. For the preparation of manganese-copper alloys it is always preferable to first melt alloys with a high content of manganese—for instance, 70 per cent of copper and 30 per cent of manganese.

If ferromanganese is used, even of the best quality (about 80 per cent of manganese, 8 to 9 per cent of iron, the balance being carbon and traces of other elements), iron is always introduced into the copper. The elasticity of the alloy and its fire-resisting qualities are thereby diminished, as is shown by extensive comparative tests. The ordinary copper-manganese will, therefore, contain always 2.5 to 4 per cent of iron for 25 to 30 per cent of manganese.

Pure manganese easily alloys with the copper, with very small loss. This represents another advantage over ferromanganese. The higher price of pure manganese is counterbalanced by the uniformity and improved quality of the castings. These can only be obtained by the use of pure manganese. Such castings are, of course, made from the best electrolytic copper.

In these alloys manganese fulfills two purposes. First, it

is a de-oxidizing agent. In general, an addition of about $\frac{1}{4}$ per cent of manganese is sufficient. Compared with other de-oxidizing agents, like phosphorus, manganese has the great advantage that if a surplus quantity is added, it improves the quality of the bath (the only exception being the case of bronze rich in tin). If too much phosphorus is added, it impairs the quality of the bath. In some cases, besides phosphorus, about 1 per cent of manganese is added.

Secondly, manganese is used to a large extent to improve the qualities of a great many metallic alloys. It combines easily with and has a great affinity to oxygen. Moreover, since manganous oxide slags are very fluid and have a low specific gravity, they easily and quickly separate out of the baths.

The practical applications of manganese are based on the principles just given. Manganese, either in the form of the pure metal, or, what is better, in the form of a high-percentage manganese alloy, is added in pieces of hazel-nut size to the molten metal bath in the crucible which is still in the furnace; after thorough stirring, the crucible is left for a certain time in the furnace at a steady temperature. The manganese slags then separate. Before adding the manganese the copper slags must be carefully removed.

All castings with manganese alloys are to be made under exclusion of air as far as possible. It is, therefore, useful to sprinkle a small quantity of borax upon the surface of the metallic bath in the crucible. It then forms a thick plastic slag.

High-percentage *manganese-copper* alloys are made by first melting the copper in a graphite crucible. Manganese, in the size of hazel nuts, is then added gradually by portions of 10 to 20 pounds, and the bath is thoroughly stirred. Before adding the manganese, the copper slag has to be removed. The metal must be repeatedly stirred, and after 5 to 10 minutes' interval the next portion of manganese is added until the whole charge is complete. If the bath contains an alloy of only 20 per cent of manganese it must be heated for an hour; in the case of an alloy of 30 to 50 per cent, heating for an hour and a half is necessary. The bath must be stirred at intervals. It takes altogether 2 to 3 hours to complete a crucible charge of 20 to 30 per cent manganese-copper.

High-percentage manganese alloy is best cast in the form of thin flat rods which can then be cut into narrower strips. In this form they are more easily used for the preparation of other alloys. However, it is still better to pour the original alloy into water, so that it assumes a granulated form. The small pieces thus formed—often hollow globules—facilitate the preparation of new alloys. For a 100-lbs. charge of 30-per-cent manganese-copper 75 pounds of copper and 32 lbs. of manganese are required. The loss is therefore small. The waste of the preceding charge is placed in the crucible containing the fluid copper. Before adding the manganese the resulting highly-fluid slag must be removed.

Manganese alloys with tin and zinc can also easily be prepared; generally the following proportions are used: Twenty parts of manganese to 80 of zinc, free from lead; 50 parts of manganese to 50 parts of tin, free from lead. The slag formed on the molten tin and zinc must, of course, be removed before adding the manganese, and the charge is kept heated for a couple of hours. With zinc it is important to take care that the temperature remains constant and does not increase. The loss in the preparation of 20-per-cent manganese-zinc is only 4 per cent.

An alloy of 30 per cent chromium and 70 per cent manganese is used, to prepare what is called *chromium-manganin*. It is used for the production of copper, containing chromium. Chromium-copper, containing 10 per cent of chromium, is also made by the aluminothermic method. Chromium-manganin alloys with copper as easily as pure manganese. Chromium seems to increase the elasticity of copper, while iron does not act in the same way.

Titanium may also be easily alloyed with manganese. This

alloy is put on the market as *manganese-titanium* containing 30 to 35 per cent of titanium. It is also used for the manufacture of copper alloys. In the same way *manganese-boron*, containing 20 per cent of boron, may be used.

OTHER METALS AND ALLOYS.

The aluminothermic reaction has also been applied in the preparation of *ferro-titanium*, which is used as a means of introducing titanium into steel. Other pure metals, free from carbon, have also been prepared by the same method, especially *iron, copper, tin, lead, nickel, cobalt, niobium*; while vanadium is produced, as Hittorf has shown, in form of V_2O_5 , which looks entirely like a metal.

Like chromium, fused *molybdenum* is now produced in fused state by the aluminothermic reaction. It is a metal of gray color, like steel, and has a dense structure. It contains as chief impurity about 1 or 2 per cent of iron besides very small quantities of silicon, so that its purity is 98 to 99 per cent. Molybdenum is also applied in the first place for making toolsteel, and is often used as a substitute for tungsten. Molybdenum has the property of rendering the toolsteel specially hard. The percentage in which molybdenum is used for such purposes, is much smaller than that of tungsten. Moreover, it is much easier to harden molybdenum steel than tungsten steel.

In most cases, besides the addition of molybdenum, a high percentage of chromium, free from carbon, is also added.

The great disadvantage of the ordinary commercial molybdenum in powdered form is that this powdered metal is always somewhat oxidized, and that these oxides impair considerably the quality of molybdenum-steel, and in many cases even spoil it. The fused molybdenum which is made by the aluminothermic reaction is absolutely free from oxide, so that the disadvantages just mentioned are absent, if the pure metal is used.

Since, as already stated, molybdenum is mostly used in conjunction with chromium, an alloy of *chromium and molybdenum* has been prepared by the aluminothermic process, and the use of this alloy may be preferable in many cases. This alloy contains equal quantities of molybdenum and chromium. Like all other metals and alloys made by the aluminothermic process, molybdenum is free from carbon. The latest alloy produced in this line is an alloy of 75 per cent of *molybdenum*, with 25 per cent *nickel*.

Finally, for ballistic purposes, a *nickel-tungsten* alloy calls for special notice on account of its high specific gravity (which is 14.5) combined with great strength. It is easily machined, nevertheless.

UNION ENGINEERING BUILDING.—In a letter of March 14, addressed to the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and the Engineers' Club of New York, Mr. Andrew Carnegie has donated \$1,500,000 for the Union Engineering Building. The total amount involved is not less than \$2,500,000, for, in addition to the amount given by Mr. Carnegie, a sum of over \$500,000, represents the investment in land for the three societies on West Thirty-ninth Street, between Fifth and Sixth Avenues; while the Engineers' Club has also acquired valuable land for its own purposes on West Fortieth Street, immediately facing the New York Public Library. The Union Engineering Building will probably be twelve stories in height. The three national engineering societies made trustees by Mr. Carnegie will have large headquarters there; and already several kindred bodies have made urgent requests for accommodation. There will be four or five auditoriums of different size, notably one to set 1200 to 1500 persons. Above all, there will be an engineering museum and a noble library hall, where all the libraries concerned will be grouped and consolidated, yet each section administered by its respective Society librarian, and each adding to its own specific literature, so as to avoid duplication of outlay for books or periodicals.

PHILADELPHIA SECTION MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The second meeting of this section was held on Friday evening, March 4th, in the assembly hall of the Engineer's Club. On account of the enforced absence of the secretary, who was ill, the election of permanent officers and adoption of proposed regulations and by-laws was postponed until the next meeting of the section. Mr. Carl Hering presided and Mr. C. J. Reed acted as secretary pro tem.

STORAGE BATTERY INVENTION.

Mr. Pedro G. Salom described some "Recent Experiments in Storage Batteries." Mr. Salom is the inventor and operator of the Salom electrolytic process for producing spongy lead from galena (for description see *ELECTROCHEMICAL INDUSTRY*, Vol. I., pp. 18, 488, 494), and has attempted to use this sponge, compressed, as the electrodes of a storage battery. When the sponge is compressed so as to be coherent, and yet not as solid as rolled lead, it makes a good negative electrode, but the positive electrode has so far not worked successfully, either because of the quality of the sponge or the mechanical construction of the plate. Mr. Salom has made a refined sponge by using his ordinary sponge as anode in an acetate solution, and depositing on the cathode an exceedingly fine, voluminous sponge, which is practically chemically pure lead, and so finely divided that it compresses nearly 100 into one. This clean sponge was then compressed by tamping it down wet with a maul into holes in a quarter-inch lead plate, producing buttons of exactly the same size as the buttons of a Manchester plate. The specific gravity of the buttons is 10.37, against that of rolled lead, 11.37. The diameter of the buttons is one inch.

The plate thus made was subjected to very severe treatment, being charged with one-half ampere per button for one hour, and discharged in one hour, the operation being repeated perhaps 100 times on the plate shown. With this rate of charge and discharge the buttons always retained their metallic core, while converted superficially into peroxide.

In the discussion Mr. Carl Hering remarked that the tamping down would produce layers in the button, which would afterwards separate and shorten its life. Mr. Salom explained that this was avoided by compressing at once sufficient lead to make the button, and not by tamping down successive portions. Dr. N. S. Keith stated that he had made buttons from spongy electrolytic lead in 1882, which were as solid as lead itself, but that he had not thought of using them in a storage battery. Mr. Hering stated that a certain porosity was desirable, so that discharge could be rapid, since it is the time necessary for the diffusion of acid into and out of the plate which affects the rapidity of discharge. Mr. Salom replied that the prime necessity is a plate whose material will not wash off mechanically, and hence that the greater the density of the compressed sponge, the better. Dr. R. Gahl explained that there was a limit to the porosity obtainable; that the plate must have mechanical strength, and hence a limit is set to its porosity and the rate at which it can discharge. Mr. Salom explained that he had not been attempting to get a plate of high capacity, but had tried to reach the capacity of the Manchester plate, which he considered to be the best plate yet made for central station work. He had not considered it desirable to attempt to reach high capacity by use of highly porous buttons. Mr. E. W. Smith confirmed this view, stating that the high capacity once attained in the chloride accumulator by the use of zinc chloride in the buttons, had been accompanied by a sacrifice of strength in the buttons. A controversy here arose as to when a plate expands, Messrs. Salom and Reed stating it as their experience that the plates buckle while being charged; Messrs. Hering and Smith were equally positive that the plates swell on discharging. No agreement was reached on this point. Mr. Salom closed the discussion by a number of statements, to the effect that he

had aimed to get one-sixteenth inch of the lead buttons converted into peroxide; that he had given the plate 100 or 150 charges and discharges, that the capacity had at first increased, and then kept constant; that he had kept a plate charged only over night, but that it stood well that long. The fineness of the refined sponge is shown by the fact that it can be "rotted" by the use of air, steam and acetic acid, and converted into white lead, in less than four hours, while the same process takes 3 to 5 days by the Bailey process (Mr. Zeller corrected this by naming one day) and 105 days by the Dutch white lead process.

THERMOCHEMISTRY OF THE DISSOCIATION THEORY.

Mr. C. J. Reed read a communication on "The Thermochemistry of the Theory of Electrolytic Dissociation," which was identical with the paper read at the meeting of the New York Section (see p. 65 of our February issue). Dr. J. W. Richards replied to the criticisms of Mr. Reed; Dr. Gahl and Mr. Jackson considered that the theory of electrolytic dissociation was proved rather than dispersed by the calculations of Dr. Richards, which Mr. Reed criticised.

On account of the lateness of the hour, the paper of Mr. Carl Hering on "Some Constants of Use in Electrochemistry" was deferred until the next meeting of the section.

PRELIMINARY PROGRAMME OF THE ANNUAL MEETING OF THE SOCIETY OF CHEMICAL INDUSTRY.

The annual meeting of the Society of Chemical Industry for 1904 will be held in New York City on September 8 to 10. The president, Sir William Ramsay, will deliver the presidential address at the general meeting on Thursday, September 8th, at Havemeyer Hall, Columbia University.

Mr. William H. Nichols, the president of the General Chemical Company, and of the Nichols Chemical Company, has become nominated by the council of the society to succeed Prof. Ramsay. For the second time in the history of the society an American will be elected its president. The first to enjoy this honor was Prof. Charles F. Chandler, of Columbia University, as a representative of chemical science in America, the second one is Mr. William H. Nichols, representing chemical industry in America.

The annual meeting will last three days, from Thursday, September 8th, to Saturday, September 10th. The provisional programme is as follows:

Wednesday, September 7th, at 9 P. M., at the Chemist's Club: Informal reception.

Thursday, September 8th, at Columbia University: 10 A. M., council meeting. 10.30 A. M. general meeting; address by Sir William Ramsay. 1.00 P. M., informal luncheon at a place to be announced later. 2.30 P. M., seeing New York by stages and automobiles. 7.30 P. M., annual dinner.

Friday, September 9th: Visits to manufacturing establishments. 8.30 P. M., roof garden entertainment.

Saturday, September 10th: Visits to Manufacturing establishments. 8.30 P. M., smoker at one of the New York Clubs.

Sunday, September 11th: Excursion by steamer around New York, the Sound, and up the Hudson.

It is expected that the following works will admit the guests of the society: Bethlehem Steel Co., Alpha Cement Works, Nichols Chemical Co., New York Glucose Co., Standard Oil Works at Bayonne, N. J., Consolidated Gas Co., Sugar Refining Works of Arbuckle Brothers, American Sugar Refining Co., Federal Sugar Refining Co., Pacific Borax Co., Sherwin-Williams Paint Co., Brewing plants of George Ehret, Jacob Ruppert, Lion Brewery; Lalanc & Grosjean Enamelled Ware Co., Marx & Rawolle Glycerine Works, United States Assay Office, Subway Power House (electrical equipment).

Following the meeting in New York the foreign guests will be taken on a tour through the country, the itinerary of which is the following: September 12th, Philadelphia, Pa.; 13th and

14th, Washington, D. C.; 15th to 17th, Pittsburg, Pa.; 18th to 22d, St. Louis, Mo.; 23d to 25th, Chicago, Ill.; 26th, Detroit, Mich.; 27th and 28th, Buffalo and Niagara Falls; 29th, Boston, Mass.; 30th, Boston or New York.

The date for the meeting, and for the tour has been selected by the society with the object in view of affording the members an opportunity to attend the International Congress in St. Louis during the week beginning Monday, September 19th.

If, as is very likely, the President of the United States will not be in Washington at the time of the visit there, it is hoped that a reception will be arranged for the visitors by President Roosevelt at Oyster Bay during the steamer excursion around New York, and, if necessary, changes of dates will be made to make this reception possible.

The following English committee has been appointed by the president to make the necessarily arrangements for the New York meeting:

Sir William Ramsay, Samuel Hall, Esq., Dr. E. B. Power, Dr. Boverton Redwood, Thomas Tyrer, Esq., H. Hemingway, Esq., R. W. Greeff, T. J. Wrampelmeier.

The New York Committee has been subdivided as follows: Executive committee: H. Schweitzer, chairman; T. J. Parker, secretary; R. C. Woodcock, treasurer; Virgil Coblenz and E. G. Love.

Committee of finance: William H. Nichols, chairman; Charles F. Chandler, H. A. Metz, T. J. Parker, R. C. Woodcock.

Hotel and transportation: C. B. Zabriskie, chairman; Leo Baekeland, DeLaguel Haigh, William F. Hoffmann, Clifford Richardson.

Entertainment and programme: E. G. Love, chairman;

Leo Baekeland, Marston T. Bogert, Gustav Drobegg, A. P. Hallock, G. C. Stone, Maximilian Toch. Invitation and press committee: E. J. Lederle, chairman; W. F. Fuerst, R. W. Moore, William J. Schieffelin, R. C. Schuepphaus, H. W. Wiley, D. Woodman. Reception committee: Virgil Coblenz, chairman; H. C. Aspinwall, A. C. Bedford, F. J. Butterworth, W. B. Cogswell, Thomas A. Edison, William H. Erhart, H. C. Grant, Edward Hart, J. Hasslacher, A. C. Humphreys, E. J. Lederle, William McMurtrie, William H. Nichols, Charles Pellew, William J. Schieffelin, F. Schniewind, F. M. Smith, I. F. Stone, Louis I. Waldman, F. G. Zinsser.

A ladies' committee, the chairman of which is Mrs. Charles E. Pellew, will arrange for the entertainment and comfort of ladies accompanying our guests while in New York, and similar committees will be formed in the other cities to be visited.

Local committees have been appointed at the following cities to make the necessary arrangements during the tour: Philadelphia, William Weightman, Hon. chairman; Samuel P. Sadler, chairman; Washington, H. W. Wiley, chairman; Pittsburg, K. F. Stahl, chairman; St. Louis, F. W. Frerichs, chairman; Chicago, T. B. Wagner, chairman; Buffalo and Niagara Falls, Charles E. Acker, chairman; Boston, Godfrey L. Cabot, chairman.

The New York annual meeting of the Society of Chemical Industry is the first one to be held outside of Great Britain, and it is the ambition of the American members of the Society to make it a memorable one.

It is stated that the funds which have most liberally been donated for this purpose, already amount to not very much less than \$20,000.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Electrical Manufacture of Iron Alloys.—Gustave Gin, Paris, France. Patent 753,875, March 8, 1904. Application filed July 7, 1902.

The invention relates to the production of ferrosilicon and ferromanganese, and the first step of the process outlined by the inventor consists in the formation of an alkali or alkaline earth silicate. When using barium sulphate, he introduces a mixture of broken quartz or non-clayey sand, barium sulphate and charcoal into an electric furnace, in the proportions determined by the equation $\text{SiO}_2 + \text{BaSO}_4 + \text{C} = \text{BaSiO}_3 + \text{SO}_2 + \text{CO}$. In order to prevent vaporization of a too great proportion of the barium sulphate by a too high temperature, the expenditure of energy is stated to be limited to between 40 and 50 watts per square centimeter of transverse section of the electrode. The barium silicate thus obtained is reduced in a second electric furnace, after being mixed with oxide of iron or wrought or cast iron in proportions varying with the amount of iron in the desired alloy. A quantity of carbon is added, regulated according to the quantity of oxygen to be eliminated, but not enough to reduce the barium sulphate to sulphide. For instance, in order to obtain ferrosilicon with about 20 per cent of silicon, the mixture is made according to the formula $\text{BaSiO}_3 + \text{Fe}_2\text{O}_3 + 5\text{C} = \text{Fe}_3\text{Si} + \text{BaO} + 5\text{CO}$, or when using metallic iron, $\text{BaSiO}_3 + 2\text{Fe} + 2\text{C} = \text{Fe}_3\text{Si} + \text{BaO} + 2\text{CO}$. It is stated that this operation is readily effected with a current of between 25 and 35 volts, the expenditure of energy being between 50 and 60 watts per square centimeter section of the electrode. Under these conditions only an insignificant quantity of carbide of barium is said to be produced, while the volatilization of the barium

oxide is not great. The furnace gases are led into a condensation chamber to recover the volatile substances. The production of ferromanganese is described as follows: "If it is desired to produce it at the same time as the baryta, one introduces into a convenient electric furnace a mixture of dioxide of manganese and sulphate of barium in such a manner as to produce the oxide mangano-barium according to the following formula: $\text{MnO}_2 + \text{BaSO}_4 + 2\text{C} = \text{MnO} + \text{BaO} + \text{SO}_2 + 2\text{CO}$. One thus realizes the electrical reduction as explained and according to the formula $3\text{MnO} + \text{BaO} + 4\text{C} = \text{Mn}_3\text{C} + 3\text{BaO} + 3\text{CO}$. If one has in view the production of oxide of sodium or an analogous volatile oxide in an electric furnace, one can carry out the first operation in a muffle furnace having a magnesia body and by substituting for the sulphate the corresponding sulphide according to the equation: $9\text{MnO}_2 + \text{Na}_2\text{S} = 3\text{Mn}_2\text{O}_3 + 2\text{Na}_2\text{O} + 2\text{SO}_2$. The electrical reduction is effected according to the following formula: $3\text{Mn}_2\text{O}_3 + 2\text{Na}_2\text{O} + 17\text{C} = 3\text{Mn}_3\text{C} + 2\text{Na}_2\text{O} + 14\text{CO}$. When it is desired to produce an iron alloy at the same time as the oxide of sodium, this oxide is volatilized in an electric furnace and can be collected by sublimation in a dust chamber, or by means of steam." The apparatus used by the inventor is illustrated in Fig. 1. A is the electric furnace in which reduction takes place. The sulphurous gases pass into a cooling apparatus B, whence they enter a chamber C, where they are dissolved in cold water injected through an atomizer. Pump D then passes the solution into apparatus B, where it passes through a mass of coke into which hot air is forced. "Under the simultaneous action of the furnace heat and injected air a mixture of air and sulphurous anhydride is disengaged from the solution and passes into the chamber E,

where it is dried by contact with the sulphuric acid. It is then passed into an apparatus F, adapted to change the temperature, in which it is heated by contact with the oxidated gases coming from the catalytic apparatus G. It passes subsequently into the latter apparatus, where the sulphurous anhydride is formed into sulphuric anhydride, which is collected in a suitable condenser, indicated in the drawing at HH."

Electric Furnace.—Charles Albert Keller, Paris, France. Patent 754,656, March 15, 1904. Application filed January 17, 1902.

The furnace is illustrated in vertical and horizontal cross-section in Fig. 2. It is intended to work in conjunction with

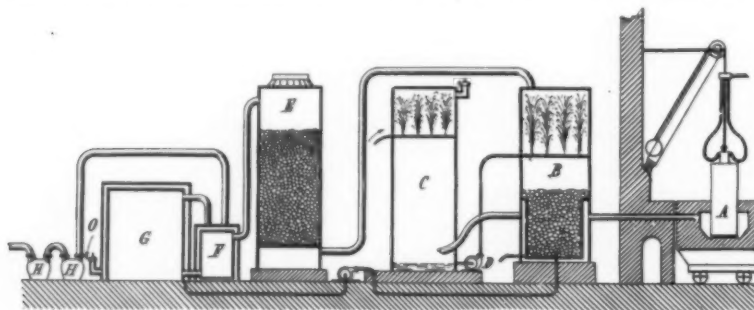


FIG. 1.—MANUFACTURE OF IRON ALLOYS.

a second furnace, which is to serve exclusively for the refining of the metal produced in the first furnace. Only the construction of the latter is described in the specification, it being stated that "any suitable electric furnace might be employed for refining, as may be convenient; but that which defines the peculiarity of this furnace in the present invention is the exclusive use of its capacity as a receptacle for metal prepared in a continuous manner in the upper furnace." The upper furnace is provided with a charging apparatus, and its upper part is constructed as a shaft furnace. Four vertical electrodes, A, B, C, D are located at the four corners of a square, and dip into a refractory vessel E, which constitutes the fusion chamber. Means are shown by which the electrodes can be vertically adjusted. The electrodes A and B are connected in parallel with one electric pole and the two other electrodes C and D, with the other pole. An arc is thus created at four points in the furnace, and four ampere meters K, arranged in the circuits connecting the electrodes, permit equalization of the intensity of the current at these four points. Two voltmeters L permit regulation of the voltage between the electrodes A and C and B and D. The tapping hole of the upper furnace discharges the metal through suitable conduits upon the base of the lower furnace. With the disposition of the electrodes as above, the operation is said to be continuous, as one of the four electrodes may be easily replaced during the operation without stopping the apparatus. During this replacement the total current passes through the other pair of electrodes.

ELECTROLYTIC PRODUCTION OF METALS AND COMPOUNDS.

Process of Preparing Electrodes.—G. J. Atkins, Tottenham, England. Patent 754,114, March 8, 1904. Application filed October 6, 1903.

In order to prevent the disintegration of carbon electrodes, the inventor saturates them with oxidizable oil, such as linseed or cotton-seed oil. In some cases he mixes lamp black or any other finely divided carbon with the oil, before saturating the electrode material with it, whereby, he claims, the conductivity of the mass is improved and disintegration still more effectually prevented. The saturation of the electrode with oil is effected by placing it into a bath of the oil and letting it absorb as much as it will. After removal from the oil bath, the electrode is preferably allowed to stand for a time, in order to allow the oil to oxidize more or less, and is then

placed in the electrolytic cell. It is claimed that the oil fills up the interstices between the particles of carbon, and does not interfere materially with the conductivity of the carbon mass, as it only fills up spaces which do not act as conductors; after the mass is saturated, the oil gradually oxidizes, especially after the saturated electrode is put to work in a cell, and it thus forms an insoluble material, which is unattackable by the electrolyte and will not melt and run away from the electrode, when the latter becomes heated in the course of the electrolytic operation. Paraffine, beeswax and other fatty matters used for this purpose are claimed to be inferior for the latter reason.

Electrode.—G. J. Atkins, Tottenham, England. Patent 753,819, March 1, 1904. Application filed April 8, 1903.

The invention relates to the treatment of carbon electrodes, so as to insure an even or uniform introduction of the current to the entire mass of the electrode. The conductor, intended to deliver the current to the carbon, is made of a sheet of metal, e. g. lead or copper. In order to prevent the electrolyte from gaining access to this conducting plate and destroying it, there is interposed between the carbon electrode proper and the conducting plate a layer composed of finely divided carbon that has been combined

with non-oxidizable oil, such as ordinary mineral lubricating oil. It is claimed that such a layer is not only water-proof,

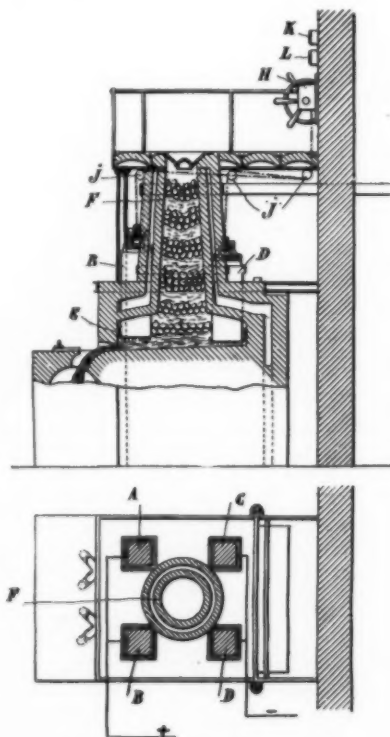


FIG. 2.—REDUCTION FURNACE.

but is a comparatively good electric conductor. A transverse section of an apparatus with an electrode constructed according to this invention is shown in Fig. 3. The electrolytic vessel *a* contains the sheet metal conductor *b*, preferably made of lead, which receives current from the main conductors *c*. The carbon anode *c* may be made of bricks of molded coarbon, or of bricks cut out of gas retort or any other suitable form

of carbon. The layer *f* composed of finely divided carbon combined with the non-oxidizable oil is rammed into the space between *b* and *c* care being taken that only just so much non oxidizable oil is used as will cement the particles of carbon together and fill the interstices between them sufficiently to prevent the passage of liquid through them. Heavy petroleum lubricating oil is stated to be suitable; *d* is a revolving cathode of lead or platinum. When applied to a flat electrode, the sheet metal conductor is covered on both sides, and at the edges with a layer made up as described above.

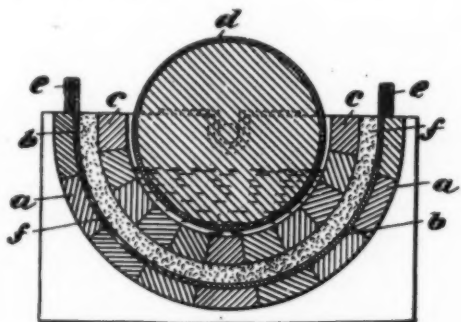


FIG. 3.—CARBON ELECTRODE.

Manufacture of Sulphuric Acid.—P. G. Salom, Philadelphia. Patent 755,247, March 22, 1904. Application filed June 17, 1902.

The principle of operation in this process is the oxidation of sulphurous acid gas in the presence of water by means of electrolytic action. The apparatus proposed for carrying out the process is shown in the adjoining Fig. 4. Dish-shaped receptacles *A*, *A'*, *A''*, etc., to *Aⁿ*, are arranged in the form of a stack on the base *B*. Each vessel is supported on the top rim of the next one below it by means of a flange *a*, separated from the rim of the under vessel by a gasket *b* of rubber. Rubber tubes *c* lead from the top of one vessel into the bottom of the next one above, and are preferably arranged alternately at opposite sides. A tube *d* leads into the bottom of the lowest vessel *Aⁿ*, and is provided with a two-way cock *D*, in order to make connection either with the source of the sulphurous acid gas *r* with the receiving tank for the sulphuric acid produced. A tube *E* which leads from the top vessel can be connected either with an air pump or other source of pressure, or with a water supply. The positive pole of the current is connected to the lowest vessel, while the negative pole is attached to the uppermost vessel. The various vessels are filled with water to the levels indicated by *f* and sulphurous acid gas is admitted through pipe *d* and allowed to rise up through the water in all the vessels, while at the same time electrolysis is allowed to take place. The gas not absorbed in the solutions and the hydrogen evolved in the process pass out through the tube *E*. The oxygen set free by electrolysis is stated to combine with the sulphurous acid to form sulphuric acid in solution, and the operation is stated to be conducted until the maximum quantity of the product has been obtained in the lowest tank. The cock *D* is then turned and the supply of sulphurous acid thus shut off, while pressure is applied through pipe *E* and the solution forced out from each upper vessel into the next lower one, while the lowest discharges its contents into the receiving tank. When a quantity of solution equal to the contents of the lowest tank has been discharged, the connections are established as they were before, the uppermost tank filled with water, and the operation resumed as described above. No details as to voltage and current strength and density and results obtained are given in the specification.

Extraction of Copper from Comminuted Mineral Mixtures.

—E. A. Le Sueur, Ottawa, Canada. Patent, 755,302, March 22, 1904. Application filed, May 27, 1899.

A process of extracting metallic copper from mixtures, containing but a very small percentage, usually less than 1 per cent of the metal. Certain cupric compounds, the hydroxide being preferred by the inventor, in solution in ammonia or its carbonate, will slowly oxidize metallic copper. The inventor claims to have discovered that such a solution has its oxidizing powers extraordinarily enhanced by the addition of certain apparently inert salts of ammonia, the sulphate and the nitrate being preferred for this purpose. The use of ammonium chloride is referred to as being objectionable on account of the danger of the formation of nitrogen chloride in case electrolytic precipitation be adopted. The composition of the solvent solution is given as $\text{Cu}(\text{OH})_2 + \text{X NH}_4(\text{OH}) + (\text{NH}_4)_2\text{SO}_4 + \text{ag}$, in which formula *X* is greater than 2 and ammonium sulphate may be replaced by other salts of ammonium. When this solution is applied to the mixture containing copper, *e. g.*, the waste sands from the Calumet and Hecla Mining Co., the cupric hydroxide is stated to be reduced, sometimes completely, to the cuprous form, according to the equation $\text{Cu} + \text{Cu}(\text{OH})_2 + \text{X NH}_4(\text{OH}) + (\text{NH}_4)_2\text{SO}_4 + \text{ag} = \text{Cu}_2(\text{OH})_2 + \text{X NH}_4(\text{OH}) + (\text{NH}_4)_2\text{SO}_4 + \text{ag}$. The copper may be extracted from this solution either

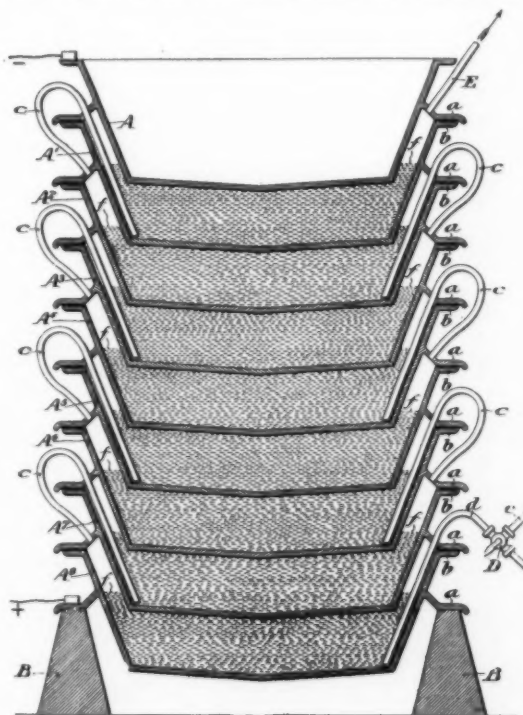


FIG. 4.—APPARATUS FOR MANUFACTURE OF SULPHURIC ACID.

by electrolysis or by chemical precipitation. The proposed method of working, where it is practicable to do so, is to dissolve the copper without (or with but little) access of air to the cuprous form, and to electrolyze this solution with an insoluble anode, with exclusion of the air. In this case the oxygen set free at the anode will oxidize half of the cuprous solution to the original cupric solution, and the copper from the other half will be deposited, the amount deposited per unit of current being twice that which would be obtained from a cupric solution. The re-oxidized cupric solution is then available for use again for leaching purposes. On account of the unavoidable waste of solution and atmospheric oxidation in

practice, the above statement is not strictly true, but it is claimed that these processes may be regulated so as to just neutralize each other and keep the amount of cupric copper at the end of any run constant. Platinum is proposed as material for the insoluble anodes. Iron and carbon anodes are also mentioned, the product of electrolysis at the anode in the first case being ferrous iron soluble in ammonia, which is afterwards oxidized by air to the ferric form and precipitated. The chemical method of extraction proposed by the inventor consists in adding to the solution a quantity of chamber sulphuric acid less than sufficient to neutralize the ammonia and filtering of the precipitated hydroxide of copper. The ammonia is left in excess in order to avoid an acid reaction and to retain a certain amount of copper in the solution in order to use the latter over again.

STORAGE BATTERIES.

Process of Preparing Electrodes for Storage Battery Cells.—O. Frank, Detroit. Patent 753,383, March 1, 1904. Application filed May 2, 1903.

The first step in this process consists in placing the lead grid-form plates into an electrolyte composed of a mixture of 95 per cent H_2O , 5 per cent of Na_2SO_4 and 0.7 per cent of $KClO_3$. Usually 11 plates are treated at one time, 5 being positive and 6 negative. The mixture is electrolyzed for about 50 hours at a temperature of about $20^\circ C$, with one ampere. It is claimed that by this treatment the positive plates are penetrated to the depth of 1 mm, with chlorine, which can be noticed by the white coat with which the plates are covered; it changes, however, shortly to a dark brown color. The plates are then thoroughly washed in distilled water, and put into a weak solution of H_2SO_4 , in order to remove the chlorine; to make the removal of chlorine complete, he uses the positive as negative plates and substitutes sheets of lead for the positive plates. He then connects up as before and charges with a current of two amperes for about 50 hours. At the end of this time the peroxide is said to appear, the brownish color of the plates being replaced by a grayish spongy coating. The plates are then taken out, thoroughly washed in distilled water, and dried in air at a temperature of $300^\circ C$. This treatment is claimed to give the plate a solid coating of lead superoxide, the plate being then taken for a practical positive plate, and the active material introduced into it.

Storage Battery Tray.—Thomas A. Edison, Llewellyn Park, N. J., assignor to Edison Storage Battery Co. Patent 754,858, March 15, 1904. Application filed November 28, 1902.

The storage battery tray described in the specification consists of a box with solid bottom and ends, open top and substantially open sides, and adapted to hold four cells. Provisions are made for the purpose of minimizing the danger of short circuiting through moisture, and details are also given as to the construction adopted for holding the cells securely in place. The best results are stated to be secured when the tray is formed of cypress, as this wood appears to be less affected by alkaline solutions. The wood is preferably paraffined, the latter operation being performed by immersing the wood either in bulk or boards in a bath of molten paraffine, in the presence of a partial vacuum produced by a vacuum pump.

Reversible Galvanic Battery.—Thomas A. Edison, Llewellyn Park, N. J., assignor to Edison Storage Battery Co. Patent 754,859, March 15, 1904. Application filed November 28, 1902.

The battery receptacle is preferably made of thin sheet-steel carefully nickel plated and with corrugated sides, provided on its inside with a lining of hard rubber or other insulating material. The bottom of the receptacle is formed with a series of bosses, which extend through corresponding open-

ings of a nickel-plated plate, which rests on the bottom. This plate is provided with ears which engage a series of glass rods, preferably formed with slots or grooves, which serve the purpose of receiving the bottom ends of the vertical electrode plates and properly spacing them and holding them in place. The vertical electrode plates carry sectional corrugated perforated nickel-plated spring steel pockets, which contain the active material. A series of glass tubes, which are arranged parallel to the plates within the spaces formed between adjacent pockets and rest on the bottom plate mentioned above, are used for the purpose of separating the plates mechanically and insulating them electrically. It is claimed that the use of glass insulators makes a very light and cheap construction, while at the same time the insulators are absolutely unaffected by electrolytic action in the alkaline solution.

Storage Battery.—M. C. Burt, Chicago. Patent 754,969, March 22, 1904. Application filed August 13, 1903.

The cell consists of two positive and three negative plates. In order to counteract the heat created in the cell the inventor arranges a pipe of any suitable "insulated" material, bent into a series of parallel coils, one series of parallel coils being interposed between each two of the plates and on the outside of the two end plates. Air under pressure is forced through these coils by means of a pump, fan, etc. The adjoining series of coils are connected over the upper edges of the plates, and the lowest end of the last series of coils is connected to a similar coil on the bottom of the plates. The latter coil is provided with apertures, through which the air can pass into the battery solution. The bottom coil is also designed to keep the plates a sufficient distance above the bottom of the cell in order to prevent short-circuiting caused by particles of active material falling on the bottom, while the coils between the plate are intended to serve as separators.

Storage Battery Construction.—S. Lake, Bridgeport, Conn. Patent, 755,142, March 22, 1904. Application filed December 17, 1903.

The invention relates to that class of storage batteries in which each cell contains two series of plates, the members of each of which are connected by a common bus bar, and the object of the invention is to form this connection in such a way that plates may readily be removed without disturbing the others. A mechanical construction for this purpose is described in detail and illustrated in the specification.

GALVANIC CELLS.

Battery Stopper.—Albert Mueller, New York. Patent 754,081, March 8, 1904. Application filed October 24, 1903.

The invention relates to a stopper for batteries on vehicles, which is intended to prevent the splashing of the electrolyte out of the battery vessels. It is constructed in such a way that it allows the gases to escape, while the liquid is introduced through a vertical passage, which communicates with a transverse passage leading into the interior of the vessel. The bottom part of the stopper is thus left unperforated and the liquid splashing up against it is prevented from escaping to the outside.

MISCELLANEOUS.

Apparatus for Electrical Production of Nitrogen or Other Compounds.—J. von Kowalski and T. Moscicki, Freiburg, Switzerland. Patent 754,147, March 8, 1904. Application filed February 21, 1903.

The apparatus used by the inventors is shown in the adjoining Fig. 5; b is an alternator, and a the primary of a transformer, the secondary C supplying currents to the leads across which are arranged in parallel the "consumption branches." Each of the latter contains a pair of electrodes $e f$ in a receptacle k , to which the air or other gases to be acted upon are supplied, in series with a condenser g and an inductance coil h . In order to eliminate or materially reduce the production of a wattless component in the secondary, a main

inductance coil i is connected across the leads in parallel with the consumption branches. Each group of parallel consumption branches is in series with a group inductance coil l , so proportioned that it will maintain the original frequency of the alternating currents in all that part of the secondary circuit outside of the consumption branch, by preventing the propagation of the oscillatory currents beyond its respective consumption branch. A series of electric arcs are formed between the electrodes e and f by the charging and discharging of the condensers g , the reciprocal action of the condensers on each other producing oscillatory currents of a high frequency in each consumption branch, modified by the inductance of the coils h , whereby a stream of sparks in the

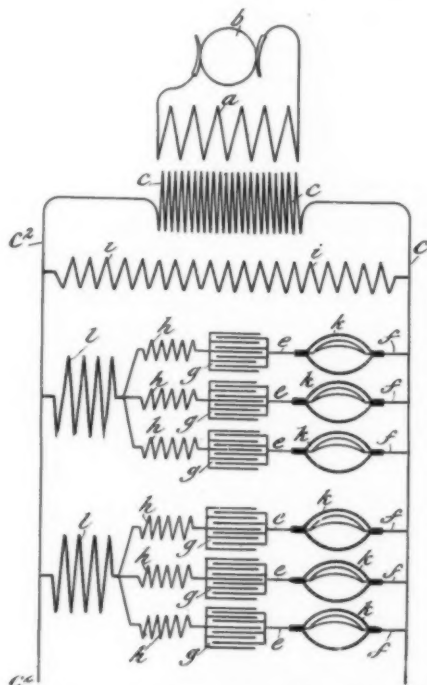


FIG. 5.—APPARATUS FOR PRODUCING NITRIC ACID FROM AIR

nature of an arc is maintained in each receptacle k . These arcs, acting upon the air or gas in the receptacle produce the desired nitrogen compounds, circulation being maintained by any suitable means. The following interesting data, taken from a plant for the production of nitric acid, are given: The secondary circuit had an e. m. f. of 50,000 volts, producing spark-arcs of about 24 centimeters in each spark gap. In each consumption branch the current was 0.05 amperes, and the frequency was about 6000 alternations per second, while the frequency of the alternating current in the secondary circuit outside of the consumption branches was 50 alternations per second. The apparatus required 33 hp. of electric energy,

and with this there was obtained 1155 grams of nitric acid per hour from the surrounding atmospheric air, or 35 grams of nitric acid per hp. hour. No attempt was made to obtain any of the other by-products, such as oxygen, nitrogen dioxide, nitrogen monoxide, etc. It was found that the frequency of the current in the consumption branch should have a minimum of 6000 alternations per second, and while the production of nitric acid was not essentially influenced up to 10,000 alternations per second, it was found advisable not to go beyond this latter frequency, because then the output of nitric acid began to fall.

Ozonizer.—A. Vosmaer, Nieuwersluis, Amsterdam, and A. Lebet, Utrecht, Netherlands. Patent 754,261, March 8, 1904. Application filed September 11, 1902.

The apparatus consists of a transformer, the secondary of which is connected with a condenser in shunt, while a choking coil is interposed in series in one of the branches between one terminal of the transformer secondary and one terminal of the condenser branch. The ozonizing apparatus, which works without any interposition of dielectrics between the electrodes, is also connected across the conductors from the secondary. The effect of the condenser is to increase the effective secondary voltage to a higher value, chiefly depending on the relation which exists between the current passing in the shunt of the condenser and that in the ozonizer. It is stated that the two phenomena resulting from the employment of the condenser (superelevation of the secondary tension and suppression of arcing) are intimately connected one with the other, and that the sparking produced in the ozonizer decreases in proportion to the degree of superelevation of the secondary voltage. Thus, the more the secondary voltage is super-elevated, providing the intensity of the current in the branch of the ozonizer is low, the better will be the production of electric effluvia which require a high tension, but a small current.

Portable Electric Lamp.—H. C. Hubbell, Brooklyn, N. Y. Patent 753,138, February 23, 1904. Application filed July 2, 1903.

The inventor describes a portable lamp, with a box of thin sheet-steel, containing a number of cells, also of thin steel and lined on the sides with thin sheet copper or brass or other metal which can be amalgamated, and is not affected by the solution. A quantity of zinc amalgam is placed in the bottom of each cell in direct contact with it. The other electrode is formed by spongy or porous pure silver, which is suitably fastened to nickel wires or iron, nickel-plated wires, suspended from a disc. The cells are partly filled with caustic potash or caustic soda solution.

Means for Providing Zinc in Radiators.—W. R. Kinnear, New York, N. Y. Patent 752,844, February 23, 1904. Application filed September 8, 1903.

The object of the invention is to prevent corrosion in sheet-metal radiators for steam and hot-water heating, by introducing a metal like zinc, electronegative to the metal of the radiator. Various forms of suspending cubes or blocks of zinc in the radiators are shown in the specification.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied INDUSTRIAL ELECTROCHEMISTRY.

Ferronickel Direct from Pyrrhotite.—One of the interesting metallurgical problems, the solution of which was undertaken during the last years in Sault Ste. Marie, was the production of ferronickel direct from the Sudbury nickeliferous pyrrhotite. A most interesting account of the manner in which this prob-

Subjects Appearing in American and Foreign Periodicals.

lem "was handled, although as yet not finally disposed of," is given by E. A. Sjöstedt in the *Iron Age* of February 18. The developed deposits of the Sudbury pyrrhotite (iron monosulfide) contain from 2 to 3 per cent nickel and 1 to 2 per cent copper, besides a variable amount of gangue. From this ore it was proposed not only to extract the nickel and copper, but

the sulphur and iron as well. The first step taken consisted in sorting the ore in two grades, of which the one of low sulphur and high gangue and copper contents was to be treated in the usual manner of matte making, whereas the ore rich in sulphur, iron and nickel, but low in copper was to be assigned to the ferronickel industry. Since the copper is present in the form of veins of chalcopyrite (Cu_2S , FeS_2), readily discerned by its deep yellows color, the separation of it, as well as that of the gangue, was accomplished on the sorting table at the rock house. In this manner they obtained a shipping ore, containing about 3 per cent nickel, 0.5 per cent copper, 28 per cent sulphur, 50 per cent iron and 0.01 per cent phosphorus—the raw material for the new industry. The *modus operandi* proposed for treating this ore was simply to eliminate first the sulphur by roasting, with the recovery of the evolved sulphur dioxide gases for the manufacture of a sulphite liquor for the then contemplated sulphite pulp mill, and second, to convert the desulphurized (now an oxide of iron and nickel) ore into a ferronickel pig either by electric smelting or by the usual blast furnace process.

It was first attempted to treat the ore, finely crushed in a Herreshoff pyrite roaster; but this kiln (which was designed for roasting pyrites, *i. e.*, bisulphide of iron, instead of pyrrhotite, *i. e.*, monosulphide of iron) did not fill the requirements, the low sulphur contents of the ore being insufficient to keep up a continuous roasting heat under the circumstances. Sjöstedt designed, therefore, a new roasting furnace and took special care to eliminate the loss of heat by radiation, to apply the roasting heat generated to the best advantage, to exclude any excesses of air over and above that required for the oxidation of sulphur, and to supply an auxiliary source of heat in case of need. The new Sjöstedt roaster (which was found entirely successful in the solution of the problem of getting a sufficiently strong gas from pyrrhotite, suitable for the manufacture of sulphuric acid and sulphate liquor, as well as for liquid sulphurous anhydride) embodies the following special features: The combination of four single furnaces in one battery, disposed equidistant from a common center; a minimum distance from the bottom of the floor to the top of roof arch of each heating chamber made possible by the construction of the arm and the manner in which it is secured to the center shaft, it being pushed home into position simply by a straight (not lifting) motion and a quarter turn twist; a round rabble arm, cast hollow, but having both ends closed so as to prevent any inflow of air from the center shaft to the roasting chamber, the air for combustion being admitted through special pipes, provided with valves for control; a secure locking device of the arm to the shaft; separate muffle chambers for applying auxiliary heat, having no connection with the roasting chambers; a screw device for feeding the ore from the hopper to the roaster.

Four of these batteries of kilns, *i. e.*, in the whole 16 units, were used with a total capacity for treating 40 tons of ore per day. At first water-gas was used for providing a required auxiliary heat, but by gradually improving the details of the

roasters, they finally succeeded in roasting pyrrhotite without any extraneous fuel, even when averaging below 20 or 25 per cent sulphur, producing a roaster gas with 7 to 9 per cent sulphur dioxide, and a ferronickel cinder with 1 to 3 per cent of sulphur. At times they succeeded in reducing the sulphur contents of the ore to 0.75 per cent, but in doing so the roaster gas naturally became weak and unfit for the sulphite mill, whereas, when making a rich gas for the mill the sulphur contents invariably increase. The author therefore suggests to divide the roasting operation in two separate stages, the object of the first being an increased product, a strong gas and only an incomplete roasting, leaving the ore with a sulphur content of about 4 to 5 per cent, and the second operation aiming at a final dead roasting of the still hot fines in an auxiliary furnace and by means of a highly oxidizing heat.

The first intention was to subject the roasted fines to electric smelting, and for this purpose an electric furnace was constructed, as shown in Fig. 1, and containing a rectangular water-jacketed body case, A B, with refractory lining, A' B', provided with a slag notch, H, vent holes, a^o , and stoke holes, b^o , a water-jacketed bottom frame, C, held removably on that body, and provided with a refractory lining on a plate, C', screwed to that frame, and having a tapping-hole, I, provided in one of the ends; a cover of refractory material D, having feed and vent holes, d and d' , and opening for the electrode; an upper electrode, K, and a bottom electrode, L, embedded in the bottom lining, C', and its ends in contact with the metallic frame of the bottom.

In this furnace a ferronickel pig was made from a poor roasted pyrrhotite, with about 3 per cent sulphur, and 53 per cent iron, at the rate of 60 pounds per hour, "with an electric energy* of 108 kw. (135 amperes, 80 volts = 144 hp.)." The same power produces, therefore, per year, 225 gross tons, corresponding to an expenditure of energy equal to 144 hp. year. Hence, the production of one gross ton requires the expenditure of 0.64 hp. for one year, or of 230 hp. for one day, or of 5000 hp. for one hour. With a furnace of 300 to 500 hp.,

which he considers would be more economical, he thinks that 180 to 200 hp. would probably suffice for obtaining a gross ton of metal per day. But even at that rate the intended plant for the manufacture of 50 tons of ferronickel pig per day would require an electric installation of 10,000 hp., which meant more time and expenditure than was considered necessary; consequently, it was decided to dead roast the ore, briquette the roasted fines and convert the briquettes, together with a proper addition of non-nickeliferous iron ores, by the ordinary blast furnace process into a pig of desired nickel contents, subsequently treating the same by the Bessemer or open hearth methods for the manufacture of a ferronickel steel.

Recent Advances in Electrochemistry.—A series of three Cantor lectures on this subject is being delivered by B. BLOUNT, the first lecture being given in abstract in London

* there is some mistake in these figures, since the electric power, corresponding to 135 amperes and 80 volts is 10.8 kw., not 108 kw.

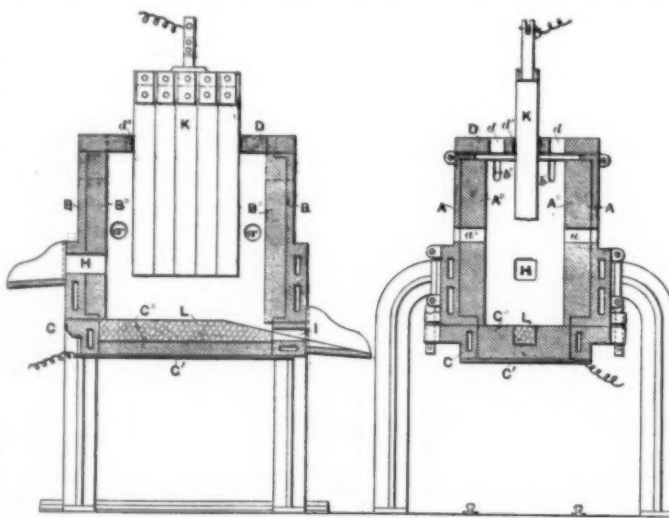


FIG. 1.—FERRONICKEL FURNACE.

Electrician March 11. In commencing, the lecturer stated that the electrochemical industries, at the present time, appeared to be passing through a transition stage. Competition between chemical and electrochemical methods of manufacture is considered by him as extremely beneficial, since it tends to stimulate workers in both fields to further exertions. As a result, he finds that any electrochemical process which has to compete with purely chemical methods, is in a more flourishing condition than those which have no competition to fight with. As an example of the latter class he cites pure carbonates which can only be produced electrolytically, and therefore this particular branch of the industry is not in quite so healthy a condition as it might be. The electrolytic "winning" of copper is much more difficult than its refining, which latter now depends to a large extent on engineering and not so much on the operator's scientific knowledge of electrochemistry. He thinks the multiple system of cells to be better than the series system, although much depends on convenience. Americans have taken the lead in the electrolytic copper refining industry, owing to the fact that they have successfully endeavored to reduce the labor and handling expenses. Dealing next with zinc, the lecturer said that there is no demand for the pure metal, and in any case it can be produced in a pure state by distillation, which method, however, is expensive. It can be prepared electrolytically from an aqueous solution, but when the latter is slightly acid, then an inconveniently high e. m. f. is required; on the other hand, when it is neutral or slightly alkaline, the zinc is obtained in a spongy form. He thinks that one may hope for success in obtaining zinc from a fused salt. Concerning nickel he said that "there are difficulties in separating it from its alloys, and pure nickel produced electrically is hardly known now, owing to chemical competition. It would pay to make a copper-nickel alloy and deposit copper only, recovering the nickel chemically." The lecturer expressed considerable scepticism as to electrolytic processes for the production of lead, and said that electrical methods, no matter how ingenious, cannot compete with existing methods.

Electric Smelting of Complex Sulphides.—In the *Engineering and Mining Journal* of March 24th, A. A. BEADLE discusses the problems involved in the treatment of the ores of the Broken-Hill saddle reef in New South Wales, which consist of an extremely finely interlaced mass of crystals of argentiferous galena and ferruginous zinc blende with a gangue of garnet, rhodonite and feldspar, together with traces of arsenic, copper and gold. The average composition of the ore is lead 18 per cent, zinc 20 to 25 per cent, iron 6 per cent, sulphur 20 per cent, gangue 25 per cent, silver 10 to 15 ounces, and gold 2 to 3 dwt. per ton, leaving about 10 per cent for moisture. At present about five tons of ore, having a total metallic value of about \$150, are concentrated in order to obtain one ton of concentrates, assaying 60 per cent lead and 31 ounces silver. Magnetic concentration has lately enabled a zinc blende assaying 45 per cent zinc, to be produced. In view of the structure of the ores, the complete separation of the metals makes it necessary to chemically disintegrate or dissolve the complex minerals. This has been tried either by means of an electrolysis of aqueous solutions, or by electrolysis of fused salts. In the electrolysis of aqueous solutions it is necessary to bring the minerals into solution either separately or, if dissolved together, they must be separately deposited in a pure and coherent condition. None of these essentials, as a matter of fact, have ever been fully realized in any of the numerous processes devised for this purpose, and which are briefly sketched by the author. Nevertheless, the large margin of profit in working one of these complex ores warrants a continuation of investigations in this direction. If we have an ore assaying lead 20 per cent, zinc 20 per cent, and silver 10 ounces, the total metallic value is about \$37 per ton. Now, if the cost of mining is \$3 per ton, the carriage by mail to the Australian seaboard \$3.50, the cost of transport by sea to Europe \$6.25, and the cost of bagging,

loading and unloading \$2.50, the margin of profit in Europe would be \$22; whereas, at the Australian seaboard, while allowing for carriage of the metals to Europe, it would be \$28 per ton of ore. This, however, does not allow for miners' rights and profits. In order that the metals—lead, zinc and silver—may be reduced electrolytically in the fused state, they must be first converted into their haloid salts. Once this is successfully accomplished they can be dealt with almost as desired, for the fused chlorides are readily amenable to fractional electrolysis, and the impurities being removed at a preliminary step, the metals may be reduced in pure marketable condition, and even the noble metals removed as a rich lead alloy before the bulk of the lead is reduced. The current efficiency is high, the voltage low, and the size and cost of plant for a given output are considerably lower than in wet processes. The conversion, therefore, either directly or indirectly, of the complex sulphides into the fused chloride constitutes the main part of this problem. The author refers to the Swinburne-Ashcroft (which was described at length in *ELECTROCHEMICAL INDUSTRY*, August, 1903, page 412). He thinks that the results so far obtained are such that great hope of the ultimate success of this departure is reasonably held out. He finally points out that in order to smelt a complex ore by a substitution method the whole of the zinc in the ore and that used in replacing the lead and silver must be entirely recoverable without loss, a state of affairs realized by electrolytic methods alone.

Treatment of Copper Ores by Means of Ferric Sulphate.—In *Metallurgie* January 15, February 8 and 22, r. THOMAS gives the results of a series of laboratory experiments, in which he investigated the problem of leaching copper ores by means of ferric sulphate. The ore with which he experimented had the following composition: 44.7 per cent SiO_2 + gangue; 13.5 per cent Cu_2S (corresponding to 10.5 per cent of copper), 25.25 per cent Fe_2S_3 , 5.76 per cent Fe_2O_3 , 0.18 per cent MnO , 7.5 per cent Al_2O_3 , 0.34 per cent P_2O_5 , and 2.82 per cent CaO , with small traces of Sb, Sr, Mg and K. The main results of his experiments are as follows: The double sulphides of copper, which occur in nature, require for their complete transformation by means of ferric sulphate such a long treatment and so fine crushing, that a commercial application of this method of leaching does not pay under the conditions existing in most countries. Copper-iron sulphides, artificially prepared, also resist the action of ferric sulphate in the same way as the natural ones. Free copper sulphides and oxides react with ferric sulphate in aqueous solution easily and quickly. The reason to which the delay of the action of the ferric sulphate in the former cases is due must, therefore, lie in the chemical affinity between the ingredients of the natural and artificial sulphur ores in the copper ore. The presence of a larger quantity of ferrous sulphate in the solution impairs the solution of copper from cuprous sulphide by means of ferric sulphate. The method suggested in the Siemens & Halske process for roasting copper ore, so that the main quantity of the iron is transformed into oxide while the main quantity of the copper remains as cuprous sulphide, is practically impossible. Neither can satisfactory results be obtained by means of dead-roasting of sulphide ores, for the reason that at the temperatures required for this purpose basic silicates are formed by means of a combination of the copper oxide with the silicates of the gangue, and that perhaps also salts of the type Fe_2O_3 are formed by combination of the oxides of copper and iron; such salts are acted upon very slowly by ferric sulphate. The double sulphides must therefore be destroyed by means of a method of oxidizing roasting at so low a temperature that the formation of the compounds just mentioned is impossible. This temperature is about 450 to 480 degrees. The product thus obtained contains the copper, essentially in the form of sulphate. The low temperature of roasting permits the use of simple furnaces, and a crushing of the ore is sufficient, corresponding to 484 meshes per square centimeter. The

leaching can be so conducted that a solution consisting essentially of copper sulphate is obtained with only small quantities of iron.

Nickel Refining.—In the issue of *Metallurgie* of March 8 E. GUENTHER describes laboratory experiments which he has made on the direct electrolytic treatment of concentrated nickel matte, obtained from New Caledonian ores, and having the following composition: Ni and Co 75.90 per cent, S 23.89 per cent, Fe 0.41 per cent, Cu 0.16 per cent, SiO_2 0.10 per cent. His main test was made with a vessel of 3 liters contents, and the run covered forty days (except at night and on holidays). Two anode plates of 15 mm. thickness and of 847 and 725 grams weight were placed at both sides of a cathode of sheet nickel. The active surfaces were about 200 sq. cm., if the surfaces, opposite to each other, are counted. He used generally a current density of 250 amperes per square meter, the voltage at the terminals of the bath being about three. Exceptionally higher current densities up to 350 amperes per square meter, and lower ones down to 100 amperes were used; in the latter case the voltage decreased to 1.5 volt, or below. He could not find any considerable influence of the current density, but recommends for several reasons which are not stated, 250 to 275 amperes per square meter. The ampere hour efficiency was in the beginning 92 per cent and decreased later gradually down to 80 per cent, for reasons not exactly determined; he believes that the decreasing size of the anode plates has to do with this phenomenon. "The electrolysis is conducted advantageously at a higher temperature," but no exact data are given. Nickel sulphate was used as electrolyte, but from his experience the author concludes that nickel chlorides may also be used. During electrolysis the anode plates are dissolved, especially at the edges, and on the sides, opposite to the cathode, the solution being apparently absolutely uniform. After a longer time the reverse sides of the anodes also showed signs of solution. The electrolyte was repeatedly analyzed, and it was found that nickel, copper and iron go simultaneously into solution according to the composition of the anode plates. The surface of the anodes remains plane, but is covered after some time with a coherent soft mass, which, however, did not increase the internal resistance of the cell. When at times the voltage at the terminals of the cell increased, it could not be shown that this was due to the anode slime; moreover, this increase in voltage was only temporary, and never more than 0.5 to 0.6 volt. At the end of the test the anodes were reduced to plates of an average thickness of 1 mm., and of an active surface, half the original one. The anodes still were coherent plates, the weight being 22 per cent of the original weight. The cathodic nickel deposit was, throughout, satisfactory; during the forty days' test he deposited more than 1 kg. nickel on the cathode, the plate having finally a thickness of 8 mm. in the central part, and 14 mm at the edges. The structure of the cathodic nickel was dense, its composition, 99.715 per cent Ni, 0.20 per cent Cu, 0.085 per cent Fe, so that the copper dissolved from the anode was not fully deposited on the cathode, while the amount of iron was considerably reduced. The anode plates at the end of the test consisted of about 80 per cent sulphur and 20 per cent undissolved sulphides; the latter contained 51.4 per cent Ni, 1.05 per cent Fe and 12.1 per cent Cu. The electrolyte is to be kept slightly acid; the contents of free acid—either sulphuric or hydrochloric acid, etc.—should be 0.03 to 0.25 per cent. At the cathode more nickel is deposited than is dissolved from the anode; the balance is to be continually supplied to the bath in form of a concentrated salt solution.

Production of Tin from the Ores.—In *Metallurgie*, January 15 and February 8, E. BAHLSSEN gives a review of the present conditions of the metallurgy of tin. The production in 1902 in the world was about 88,279 tons, the principal place of mining being the Malay Peninsula. The principal mines are not inexhaustible, and it is probable that in about ten years the production of tin from ores will rather decrease than increase, if

new mines are not found. On the other hand, most of the tin which is now used for the tinned iron cans for preserves is afterwards won back by electrolytically de-tinning the scraps. At present about 35,000 tons of tin scraps are treated per year electrolytically in Germany, from which 2 to 2.5 per cent, i. e., about 800 tons of tin, are won, amounting to about \$500,000. There is no danger of an overproduction of tin for the next few years, and it is probable that the price will remain high.

Alkali Metals by Electrolysis of Fused Salts.—In *Metallurgie* January 15, L. STOCKEM gives some supplementary notes on his work on the production of alkali and alkaline earth metals by electrolysis of their fused salts (see *ELECTROCHEMICAL INDUSTRY*, November, 1902, p. 104). He discusses first the behavior of sodium in fused sodium chloride. The solution of sodium in chloride may either be a simple solution process, or may be due to the formation of a subchloride, like Na_2Cl , as Rose believes; the present author shows that the latter assumption is very improbable. Concerning the production of calcium by electrolysis of calcium chloride, he points out that to get a good efficiency, it is absolutely necessary to keep the temperature of the cathode so low that the formation temperature of Ca_2Cl_2 is not attained; for this purpose it is necessary that the calcium deposited upon the cathode is constantly cooled to a temperature near its melting point, although the average temperature of the fused salt may be higher. The melting point of strontium was found to be between 570° and 660° C.

Electrolytic Production of Trivalent Vanadium Salts.—In the *Zeit. f. Elektrochemie*, February 26, A. BUELTEMAN describes experiments in which trivalent vanadium salts were produced by electrolytic reduction from fourvalent salts. The production of $\text{V}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2 \text{SO}_4 \cdot 24\text{H}_2\text{O}$ by this method is first described. He employed a diaphragm cell, and used as anodic liquor sulphuric acid of the same concentration as is contained in the cathodic liquor. For the latter 100 cc. of a sulphate solution of the fourvalent vanadium was used. The voltage of electrolysis was 8 to 9 and the temperature of the electrolyte at the end of the electrolysis was 80° C. If the catholyte is then cooled in a closed vessel, $\text{V}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2 \text{SO}_4 \cdot 24\text{H}_2\text{O}$ crystallizes out in form of large crystals of a blue-violet color. This salt can exist with the same chemical compositions in two different modifications. For making $\text{V}(\text{C}_2\text{O}_4)_3 \cdot (\text{NH}_4)_2 \cdot 3\text{H}_2\text{O}$ and $\text{V}(\text{C}_2\text{O}_4)_3 \cdot \text{K}_2 \cdot 3\text{H}_2\text{O}$ he prepared the catholyte by dissolving V_2O_5 by means of oxalic acid as a fourvalent salt. This liquid was electrolytically reduced until the vanadium was all in the trivalent form. Ammonium or potassium oxalate was then added and heated, and the above-named substances were then crystallized out. It is possible to use comparatively high-current densities and the ampere hour efficiency is nearly 100 per cent.

THEORETICAL AND EXPERIMENTAL ELECTROCHEMISTRY.

The Structure of the Atom.—The electron theory has become of the greatest importance for chemistry, not only on account of its intimate relation to the ionic theory in electrolysis, but also for the reason that it threatens to break down, or, at least to modify completely our former ideas on the nature of atoms. The atom is no longer considered the smallest particle which can exist, and is now, in fact, looked upon as a complicated system of numerous electrons. J. J. THOMSON, who has already done very much for the development of the electronic, or, as he calls it, corpuscular theory, has now undertaken to study mathematically the consequences of this hypothesis, and to compare them with the facts, especially those represented by the periodic system of the elements. His extremely interesting paper is published in the March issue of the *Philosophical Magazine*. The first part of the paper is devoted to the discussion of a mathematical problem, suggested by the view that the atoms of the elements consist of a number of negatively electrified corpuscles enclosed in a sphere of uniform positive electrification. This mathe-

mathematical problem is the motion of a ring of n negatively electrified particles placed inside a uniformly electrified sphere.

Thomson shows that when we have a large number of corpuscles moving about in a sphere of uniform positive electrification, and when they are constrained to move in one plane, they will arrange themselves in a series of concentric rings. This arrangement is necessitated by the fact that a large number of corpuscles cannot be in stable equilibrium when arranged as a single ring, while this ring can be made stable by placing inside it an appropriate number of corpuscles. When the corpuscles are not constrained to one plane, but can move about in all directions, they will arrange themselves in a series of concentric shells. Now, Thomson shows that the properties which an atom would have on account of this ring or shell structure are analogous in many respects to those properties really possessed by the atoms of the chemical elements, and that in particular the properties of the atom will depend upon its atomic weight in a way very analogous to that expressed by the periodic law.

When there are N corpuscles, each carrying a charge e of negative electricity, placed in a sphere of positive electrification, then Thomson determines the distribution of the corpuscles when they are arranged in what may be considered the simplest way, *i. e.*, when the number of rings (or shells) is a minimum, so that in each ring there are as nearly as possible as many corpuscles as it is possible for the corpuscles inside to hold in equilibrium. The following table shows clearly the way in which various numbers of corpuscles group themselves; the numbers range downwards from 60 at intervals of 5. The uppermost row of figures gives the total number of corpuscles, while the lower rows give in each case the number of corpuscles as they arrange themselves in successive rings:

TABLE I.

60	55	50	45	40	35	30	25	20	15	10	5
20	19	18	17	16	16	15	13	12	10	8	5
16	16	15	14	13	12	10	9	7	5	2	
13	12	11	10	8	6	5	3	1			
8	7	5	4	3	1						
3	1	1									

We give also the entire series of arrangements of corpuscles for which the outer ring consists of twenty corpuscles. The uppermost row of figures indicates again the total number of corpuscles, while the lower rows give in each case the number of corpuscles in successive rings:

TABLE II.

59	60	61	62	63	64	65	66	67
20	20	20	20	20	20	20	20	20
16	16	16	17	17	17	17	17	17
13	13	13	13	13	13	14	14	15
8	8	9	9	10	10	10	10	10
2	3	3	3	3	4	4	5	5

Fifty-nine is the smallest number of corpuscles which can have an outer ring of 20, while, when the number of corpuscles is greater than 67, the outer ring will contain more than 20 corpuscles. The mass of an atom is the sum of the masses of the corpuscles it contains, so that the atomic weight of an element is measured by (*i. e.*, is proportional to) the number of corpuscles in its atoms. An inspection of table I. will now show that the various arrangements of the corpuscles can be classified in families, the grouping of the corpuscles in the various members of the family having certain features in common. Thus, for example, the group of 60 corpuscles consists of the same rings of corpuscles as the group of 40, with an additional ring of 20 corpuscles round it, while the group of 40 consists of the same series of rings as the group of 24, with an additional ring outside, while 24 is the group 11, with an additional ring, etc.

In general, we can divide the various groups of atoms into series, such that each member of the series is derived

from the preceding member (*i. e.*, the member next below it in atomic weight in the same series) by adding to it another ring of corpuscles. We should expect the atoms formed by a series of corpuscles of this kind to have many points of resemblance. Take, for example, the vibrations of the corpuscles; they may be divided into two sets. First, those arising from the rotation of the corpuscles around their orbits: if all the corpuscles in one atom have the same angular velocity, the frequency of the vibrations, produced by the rotation of the rings of corpuscles is proportional to the number of corpuscles in the ring; and thus, in the spectrum of each element in the series there would be a series of frequencies bearing the same ratio to each other, the ratio of the frequencies being the ratios of the numbers in the various rings. The second system of vibrations are those arising from the displacement of the ring from its circular figure. If, now, the distance of a corpuscle in the outer ring from a corpuscle in the collection of rings inside it, is great, compared with the distance of the second corpuscle from its nearest neighbor on its own ring, the effect of the outer ring of corpuscles on the inner set of rings will only "disturb" the vibrations of the latter without fundamentally altering the character of their vibrations. Thus, for these vibrations, as well as for those due to the rotations, the sequence of frequencies would present much the same features for the various elements in the series; there would be in the spectrum corresponding groups of associated lines. Thomson regards a series of atoms formed in this way, *i. e.*, when the atom of the p' th member is formed from that of the $(p-1)$ th by the addition of a single ring of corpuscles, as belonging to elements in the same group in the arrangement of the elements according to the periodic law, *i. e.* they form a series which, if arranged according to Mendeléef's table, would all be in the same vertical column.

The gradual change in the properties of the elements which takes place as one travels along one of the horizontal rows in Mendeléef's arrangement of the elements is also illustrated by the properties possessed by these groups of corpuscles. Thus we may consider the series of arrangements of the corpuscles in table II., given above, in all of which the outer ring contains 20 corpuscles. In the case of a total number of 59 corpuscles, the number of corpuscles inside is only just sufficient to make the outer ring stable; this ring will, therefore, be on the verge of instability, and when the corpuscles in this ring are displaced, the forces of restitution urging them back will be small. Thus, when this ring is subjected to disturbances from an external source, one or more corpuscles may easily be detached from it; such an atom therefore will easily lose a negatively electrified corpuscle, and thus acquire a charge of positive electricity; such an atom would behave like the atom of a strongly electropositive element. When we pass from 59 to 60 corpuscles, the outer ring is more stable, because there is an additional corpuscle inside it; the corresponding atom will thus not be so electropositive as that containing only 59 corpuscles. The addition of each successive corpuscle will make it more difficult to detach corpuscles from the outer ring, and will therefore make the atom less electropositive. When the stability of the outer ring gets very great, it may be possible for one or more corpuscles to be on the surface of the atom without breaking up the ring; in this case the atom would receive a charge of negative electricity, and would behave like the atom of an electronegative element. The increase in the stability of the ring, and consequently in the electronegative character of the atom, would go on increasing until it is a maximum for 67 corpuscles. A great change in the properties of the atom would occur with 68 corpuscles, for now the number of corpuscles in the outer ring increases to 21; these 21 corpuscles are, however, only just stable, so that the corresponding atom is strongly electropositive.

The arrangement of corpuscles in the group of 59, although very near the verge of instability, and therefore very liable to

lose a corpuscles, and thereby acquire a positive charge, would not be able to retain this charge. For when it has lost a corpuscle, the 58 corpuscles left would arrange themselves in the grouping corresponding to 58 corpuscles, which is the last to have an outer ring of 79 corpuscles; this ring is therefore exceedingly stable, so that no further corpuscles would escape from it, while the positive charge on the system, due to the escape of the 59th corpuscle would attract the surrounding corpuscles. Thus this arrangement could not remain permanently charged; for, as soon as one corpuscle had escaped, it would be replaced by another. An atom constituted in this way would be neither electropositive nor electronegative, but one incapable of receiving permanently a charge of electricity.

The group containing 60 corpuscles would be the most electropositive of the series; but this could only lose one corpuscle, *i. e.*, acquire a charge of one unit of positive electricity; for if it lost two, we should have 58 corpuscles—as, when the group of 59 had lost one corpuscle—and in this case the system would be even more likely than the other to attract external corpuscles, for it would have a charge of two units of positive electricity instead of one. Thus, the system containing 60 corpuscles would get charged with one, but only one, unit of positive electricity: It would therefore act like the atom of a monovalent electropositive element. The group containing 61 corpuscles would not part with its corpuscles so readily as the group of 60, but on the other hand, it could afford to lose two, and the system would act like the atom of a divalent electropositive element; similarly a group of 62 like the atom of a trivalent electropositive element.

The group of 67—at the other end of the series—has a very stable outer ring, but if the system acquired another corpuscle, the 68 corpuscles would arrange themselves with a ring of 21 corpuscles on the outside; which, however, would be nearly unstable. Therefore, the group of 67 corpuscles, as soon as it acquires a negative charge, would lose it again, and the system, like the group of 59, would be incapable of being permanently charged with electricity—it would act like the atom of an element of no valency. The group of 66 would be the most electronegative of the series, but this would only be able to retain a charge of one unit of negative electricity, and would therefore act like the atom of a monovalent electronegative element; similarly the groups of 65 and 64, like the atom of a bivalent, and trivalent electronegative element, respectively.

Now, this sequence of the properties which we should expect from the shell structure of an atom, is very like that observed in reality. Thus, we have the series of the elements:

He Li Be B C N O F Ne
Ne Na Mg Al Si P S Cl Ar

The first and last element in each of these series has no valency, the second is a monovalent electropositive element, the last but one is a monovalent electronegative element, the third is a divalent electronegative element, and so on. When atoms like the electronegative ones, in which the corpuscles are very stable, are mixed with atoms like the electropositive ones, in which the corpuscles are not nearly so firmly held, the forces to which the corpuscles are subject by the action of the atoms upon each other may result in the detachment of corpuscles from the electropositive atoms, and their transference to the electronegative. The electronegative atoms will thus get a charge of negative electricity, the electropositive atoms one of positive, the oppositely charged atoms will attract each other, and a chemical compound of the electropositive and electronegative atoms will be formed.

To form an idea of the constitution of the atom of a radioactive element, Thomson refers to a result, obtained by him in his analysis of the stability of systems of corpuscles; such systems may be stable when the corpuscles are rotating with an angular velocity greater than a certain value, but may become unstable when the velocity falls below this value. Thomson considers the properties of an atom containing a

system of corpuscles of this kind. He supposes the corpuscles to move originally with velocities far exceeding the critical velocity. In consequence of the radiation from the moving corpuscles, their velocities will slowly—very slowly—diminish. When, after a long interval the velocity reaches the critical velocity, there will be what is equivalent to an explosion of the corpuscles, the corpuscles will move far away from their original positions, their potential energy will decrease, while their kinetic energy will increase. The kinetic energy gained in this way might be sufficient to carry the system out of the atom, and we should have, as in the case of radium, a part of the atom shot off. In consequence of the very slow dissipation of energy by radiation the life of the atom would be very long.

Dielectric Constants.—In a paper, published in the February issue of the *Journal of Physical Chemistry*, H. SCHLUNDT gives the results of a continuation of his former work on the dielectric constants of some inorganic solvents, and on the validity of the Nernst-Thomson rule, according to which a close parallelism exists between the dissociating power of solvents and their dielectric constants. A number of exceptions to the rule had been pointed out by him formerly, and a number of new examples had been found which followed the rule. The inorganic solvents studied followed the rule in a general way, although the parallelism between the ionizing power and the dielectric constant was far from close in several instances. The author has now determined the dielectric constants of some halogen compounds of phosphorus, arsenic and antimony, and also those of phosphorus, silicon tetrachloride and nitrogen tetroxide. The dielectric constants of the compounds in the solid state was found to be less than the value for the liquid; this drop in the value occurs upon solidification and depends to a great extent on the structure of the solid. Phosphorus trichloride, phosphorus tribromide and silicon tetrachloride have no ionizing power, and a low dielectric constant, and hence follow the Nernst-Thomson rule. There is also a parallelism between ionizing power and dielectric constant in antimony trichloride, arsenic trichloride and phosphorus trichloride; the same is the case for arsenic tribromide and nitrogen tetroxide.

Molecular Depression of Freezing Point in Concentrated Solutions.—The March issue of the *Physical Review* contains a very full account, by H. C. JONES and F. H. GETMAN, of an extended study of the molecular lowering of the freezing point of water produced by concentrated solutions of electrolytes. Of special interest are the conclusions drawn by the authors on the constitution of concentrated solutions. With but few exceptions electrolytes in general give abnormal molecular depressions of the freezing point in concentrated solutions. Among these exceptions are sodium, potassium and ammonium nitrates, and potassium dihydrogen phosphate. Among the chlorides those of the second group in the periodic system give greater molecular depressions than those of the first group. The curve for hydrochloric acid lies considerably above the corresponding curves for lithium, ammonium, sodium and potassium chlorides. In general, the freezing-point curve for any acid lies above those of the salts which it forms with the metals of the first group, while it lies below the curves for its second group salts. Further, the molecular depressions for similar substances are arranged in the order of their molecular weights. The conductivity curves for all the substances studied are perfectly normal throughout, showing absolutely no peculiarities in the region of dilution where the minimum of molecular depression manifests itself. The boiling curves, as far as studied, show a minimum at a greater concentration than the freezing-point curves. The main conclusion drawn by the authors is the existence of hydrates in concentrated solutions. In such solutions there is combination between the molecules of the dissolved substance and the molecules of the solvent, thus removing a part of the

solvent, as far as freezing-point lowering is concerned. To explain the conductivity result, it is also necessary to assume that there is a certain amount of electrolytic dissociation, together with the hydration existing in these solutions.

Electrolytic Analysis of Gold.—A Faraday Society paper by F. M. PERKIN and W. C. PREBBLE on this subject is published in the *Electro-Chem. and Met.*, February. While they agree that the use of a double cyanide solution gives good deposits, yet the time necessary for the complete deposition in cold solutions is inordinately long. They are unable to agree with Classen that complete precipitation of the metal in hot solutions can be carried out in from 80 to 90 minutes. The sulphide method of E. Smith gives very brilliant deposits and in cold solutions the metal can be usually deposited in from 5 to 6 hours. The authors have found gold can be deposited in a very satisfactory manner from solutions of gold salts in ammonium thiocyanate. With current densities of 0.2 ampere per square decimeter the deposition of 0.05 to 0.08 gram in cold solutions is complete in from 5 to 6 hours. With a current density of 0.4 to 0.5 ampere per square decimeter it is generally possible, even at normal temperatures, to deposit the gold in from 1½ to 2 hours. The appearance of the deposit is generally better when obtained at a low current density and from solutions containing small quantities of gold. The authors have also carried out experiments to ascertain the best method for removing the deposited gold from the platinum cathodes. An extremely satisfactory solution is one containing potassium cyanide, with an oxidizing agent such as hydrogen peroxide, sodium peroxide or an alkali persulphate. With such a solution the deposit is removed in 2 to 3 minutes. They have also employed chlorine and bromine water successfully, but with these reagents the time required to remove the deposit is from 1 to 2 hours.

STORAGE BATTERIES.

Jungner Alkali Accumulator.—In the *Centralblatt f. Accum.*, March 1, an account is given of the Jungner accumulator exhibits at the recent Paris automobile exposition. It will be remembered that in its general mechanical construction it is similar to the Edison Accumulator. A method of Jungner for making positive nickel electrodes of the Planté type is also noticed, although it is at present more of scientific, than industrial value. Such nickel plates have a dark-brown color and look somewhat similar to peroxidized lead sheets. If the nickel peroxide is removed from the surface (by etching with dilute hydrochloric acid) a complicated structure of pure nickel appears, which is not unsimilar to moss. At present these plates have too low a capacity per unit of weight. They are formed in an electrolyte of a very dilute alkaline solution of sodium chloride, while for the second formation a 30 per cent solution of potassium hydroxide. The watt hour efficiency of the Jungner accumulator is not over 65 per cent, its ampere hour efficiency about 70 to 75 per cent. In a note in *Electro-Chem. and Met.*, February, the thickness of the nickel-plated steel from which the envelope for the active material is made is given as 0.2 mm., while the watt hours per kilogram of total weight of the Jungner cell "work out to an average of 23 to 24." M. U. Schoop thinks that a gelatinous alkaline electrolyte in the Jungner cell may be of use for ignition cells, but hardly for traction.

Lead Accumulator.—In the *Centralblatt f. Accum.*, February 1 and 15, F. PETERS continues his very long serial on the electrolytic formation of lead peroxide from metallic lead. A summary of his results will be given after the completion of the serial. The *Centralblatt f. Accum.*, February 15, gives a brief description, by H. L. JOLY, of the traction cell exhibited at the recent Paris automobile exposition. The *Elek. Neu. Ans.* of February 15 contains a note on the Lacroix accumulator, which is being made by a French company. The active material is contained in a bag of very thin gauze of an alloy, called "pontinium," and containing 15 parts of tin and 1 part

of sodium per 1000 parts of lead. A cell of 100 ampere hours capacity has a total weight of 8.5 kg.

MISCELLANEOUS.

Efficiency of Cement Kiln.—An interesting application of thermochemical methods to a problem of industrial chemistry is given in the calculation of the thermal efficiency of a rotary cement kiln, given by J. W. RICHARDS in the January issue of the *Jour. Am. Chem. Society*. The test was made on a rotary cement burner, 60 feet long by 6 feet external diameter, fired by pulverized bituminous slack coal, at the plant of the Dexter Cement Co., at Nazareth, Pa. The ground cement mixture has the following composition: Silica 13.38 per cent, aluminium and ferric oxide 6.04 per cent, calcium oxide 41.96 per cent, magnesium oxide 1.53 per cent, carbon dioxide 34.65 per cent, moisture 0.43 per cent. The burnt cement clinker contains silica 21.27 per cent, aluminium oxide 6.42, ferric oxide 3.18, calcium oxide, 66.7, magnesium oxide 2.43. The kiln turns out an average of 3635 pounds of clinkered cement per hour from 5980 pounds of mixture fed to it, producing 200 pounds of flue dust. The coal used averages 110 pounds per barrel (of 380 pounds) of cement used. The author then gives a complete calculation of the different amounts of heat generated and consumed or lost, on the basis of 100 kg. of coal used, or 2 barrels of cement made.

The theoretical heating power of the fuel is 790,000 calories, while the combination of the ingredients of the cinder also evolves a large quantity of heat, equal to 142,819 calories, or 18 per cent of the heat developed by the combustion of coal. The heat in the clinker represents only about one-tenth of the heat developed in the kiln; this is a very low proportion for an industrial operation, and leaves large room for improvement and economies where fuel is dear. The great amount of heat carried out by the products of combustion and excess of air admitted, amounting to about two-thirds of the total heat developed in the kiln, points to great savings if a kiln of double length was used, and the amount of air admitted was reduced. The author finally estimates the temperature of the mixed gases of combustion and excess of air in the kiln at 1000°, while the clinker, leaving the kiln at 1200°, is hotter. The heat of combination of the ingredients of the cinder accounts for this apparent anomaly.

Resistivity of Glass Against Chemical Action.—A practical case in which wine, having been kept in bottles of unsuitable glass, deteriorated in quality, suggested the development of a method by which the examination of the resistivity of a glass bottle against chemical action could be easily and quickly made. F. HABER and H. SCHWENKE describe in *Zeit. f. Elektrochemie*, February 26, the following electrochemical method for this purpose. The bottle is carefully cleaned with cold water and is then filled with water free from carbonic acid, and air free from carbonic acid. is passed through it for about five hours at a temperature of 80° C. Every hour the current is measured between two small platinum electrodes, while a source of e. m. f. of 10, 20 or 30 volts is connected momentarily to the two electrodes. These three measurements of the current are combined for determining the specific conductivity, and from the change of the specific conductivity from hour to hour the progressing solution of the glass in water is found. To give a numerical value indicating the quality of the glass of the bottle, the rapidity with which the glass dissolves in water is compared with the corresponding value of standard bottles which have been tested once for all.

Thermometers from Fused Quartz.—In the *Zeit. f. Elektrochemie*, February 26, C. SIEBERT discusses the manufacture of high temperature thermometers from fused quartz. Such thermometers, filled with tin, potassium, sodium, were found to be unsuitable, so that mercury had to be used again. Thermometers filled with mercury and nitrogen, under a pressure of 60 atmospheres enable one to measure temperatures up to 720° C., with exactness. The preparation of longer tubes from

fused quartz so as to have a uniform cross-section is still very difficult. These thermometers are now made in a length of 35 cm., the nickel steel scale reading from 300° to 750° C., each division representing 5° C.

Spectra of Elements.—In the *Zeit. f. Elektrochemie*, February 19, RUNGE discusses the regularities in the spectra lines of the elements. He describes what is meant with homologous lines of different spectra, and gives the rule that the logarithm of the atomic weight is a linear function of the distance of the pairs of homologous lines.

Potassium-Magnesium Carbonate.—In the *Zeit. f. Elektrochemie*, March 4, F. AUERBACH discusses the physical chemistry of the double salt $\text{MgCO}_3 \cdot \text{KHCO}_3 \cdot 4\text{H}_2\text{O}$, which is of importance in the Stassfurt potassium industry. The solubility of $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$ in solutions of KHCO_3 of varying concentration was determined at 15, 25 and 35° C. Under proper conditions the above-named double salt is formed. The results are plotted diagrammatically.

Chemical Industries in Kansas.—An article on the manufacture of sulphuric acid and blue vitriol in Kansas is published in the *Lead and Zinc News* of March 21. There are two sulphuric acid plants, at Argentine and Iola, the method being essentially the same as in other works in this country. At Argentine there is also the only plant in the United States manufacturing blue vitriol by itself, and not as a byproduct, the process being that of Ottokar Hofmann.

Lead.—An article by R. N. BELL in the *Lead and Zinc News* of March 21 gives notes on lead mining in the Coeur d'Alenes district in Idaho. The gross lead and silver contents of the concentrates and crude ores shipped out of the district during 1903 were 213,520,000 pounds of lead, and 5,751,613 ounces of silver.

Biographical.—In the *Zeit. f. Elektrochemie*, R. ABEGG gives an interesting account of the life and work of SVANTE ARRHENIUS, the famous founder of the electrolytic dissociation theory, and especially of the difficulties which he had to overcome to be recognized by the physicists and chemists in his native country, Sweden. A good portrait of Arrhenius is given.

Correspondence.

RADIOACTIVITY.

TO THE EDITOR OF ELECTROCHEMICAL INDUSTRY:

SIR—I beg the opportunity through your pages of raising my voice as a chemist, in protest against the unqualified acceptance of the prevailing theory with regard to the ultimate cause of the extraordinary phenomena presented by the salts of radium.

The most popular hypothesis at present accounts for the various rays, the emanation and emission of heat, by the assumption that the so-called atom of radium breaks down with a development of energy 1000 times greater than the highest known development of energy by chemical process from a given weight of matter.

This hypothesis is not only entirely new, but it is also diametrically opposed to the universal law of chemistry, at least to the law which has until recently been regarded as universal, that the separating of chemical bonds always means the absorption of heat, and the formation of chemical bonds always means the development of sensible heat. There are, of course, apparent exceptions to this, where the compound in breaking up reunites with a great evolution of heat, but this evolution is not from the breaking up of the old bonds, but from the forming of new. At least, this is the theory which has been universally accepted and seems to be justified by experience and sanctioned by every rational consideration.

Here, now, we have a new theory, asking us to believe on indirect evidence, that a new force of energy 1000 times more potent has been found in a process which by analogy, would

lead us to expect not the evolution of heat, but its absorption. Direct testimony in support of this hypothesis is conspicuous by its absence. The finest chemical scale, the most exact observation, fails to show the slightest loss of weight.

The whole subject of rays, other than the rays of light, has developed with such rapidity in the last ten years, and so widened the boundaries of our knowledge in directions that were hardly suspected hitherto, that it seems not only rational, but almost obvious that there must be many other forms of radioactivity, of which we, as yet, know nothing. The phenomenon of a body at a higher temperature than the medium which surrounds it, is as familiar as the fall of rain. It is true of almost any substance upon which the sun's rays are shining; may there not then be some kind of rays as yet unknown to us to which radium is more opaque than other substances, and by which it is stimulated into radioactivity and the development of sensible heat?

Here is a hypothesis that on the face of it, is in the first place not contrary to any known principle in chemistry or physics. Secondly, it is directly in line with a familiar phenomena both of the sun's rays and other rays. Cathode rays, as we know, seem to develop X-rays by contact with the walls of a glass tube.

If radium were itself the origin of the energy which it emits, why should solution in water temporarily deprive it of most of its power? If, on the other hand, it owes its peculiar properties chiefly to a certain opacity, there seems no reason why solution in water should not make it more permeable to some unknown ray, just as easily as it does to a ray of sunlight.

If, again, radium is itself the source of this energy, the energy developed ought to be directly proportionate to the weight of the radium, and the sensible heat ought to show great variation according to the mass of radium salts considered, and the shape in which they are assembled, for the escape of heat would naturally be proportionate to the surface, other things being equal, and a larger or more compact mass ought to show a higher temperature, than a small or thin mass, having a relatively larger surface.

If, on the other hand, radium is anything like as opaque to these rays as it is, for instance, to sunlight, the amount of energy developed would naturally bear a certain relation to the surface of the salts exposed to their action, but if it is only very slightly opaque, it seems likely it would require a considerable amount of radium to give us absolute proof on this point.

Far be it from me to imply that there may not be other explanations of these extraordinary phenomena, quite different from any hypothesis that has yet been broached, but I hope that this suggestion may lead to interesting experiments and further light on the subject. In this connection, let me quote from a world-famous chemist who was asked for advice on experimental work by a professor of Harvard College, and he answered "Probiren Sie Alles, sei es noch so dumm."

GODFREY L. CABOT.

Boston, Mass.

ELECTROLYTIC PRODUCTION OF HYDROXIDES AND OXIDES.

TO THE EDITOR OF ELECTROCHEMICAL INDUSTRY:

SIR A synopsis of my patent, No. 748,609, for the "Production of hydroxides and oxides of the metals by electrolysis," appears on page 112 of your issue of March, 1904; your reviewer adds that he "experienced a great deal of trouble from the deposit sticking to the electrode on reversal of the current, causing a great increase in resistance and falling off in yield."

Of all the common metals whose oxides or hydroxides are in commercial use, I find that only one of them produces the effect your reviewer mentions (and I am at work to overcome it) either on a laboratory scale or in the actual com-

mercial production of them; and such a sweeping criticism, based on unsuccessful and abandoned experiments of "several years ago" is not only misleading to your readers, but a serious injustice to the patentee, and I respectfully protest against such criticism.

New York City.

FRED. F. HUNT.

Current Notes.

MADISON LOCAL SECTION OF THE AMERICAN ELECTROCHEMICAL SOCIETY.—The February meeting of the Science Club of the University of Wisconsin was held on February 23d, in the physical lecture room of Science Hall of the University Buildings. The Madison local section of the American Electrochemical Society was the guest of the club at this meeting. The following three papers were presented: Prof. C. F. Burgess discussed the electrolytic refining of iron by a method similar to copper refining. Since an enlarged paper by the author on the same subject will be presented at the Washington meeting of the American Electrochemical Society, we will report it at that time. Prof. O. W. Brown gave a general discussion of electric furnace designs and processes and Dr. Victor Lenher spoke on the solidity of gold. His paper will be abstracted in a later issue.

ELECTROCHEMISTRY AT THE PARIS EXPOSITION.—At the International Paris Exposition, to be held from August to November, 1904, at the Grand Palais des Champs-Élysées, a special hall will be devoted to electrochemical and electrometallurgical exhibits. The exhibits will be arranged according to nationalities, and each group will be divided into sections, according to the large industrial centers or to the water-power plants on which the industries depend. Communications should be addressed to M. Adolphe Minet, Directeur de l'Electrochimie, 37 Rue de Berne, Paris.

IRIDIUM.—A marked increase in the price of iridium, the second in commercial importance of the platinum group of metals, is reported to have taken effect during the past month. This fact is of particular importance to the electrical, chemical and dental industries, which are extensive consumers of the various alloys of iridium and platinum. Recent reports indicate a very marked shortage in the supply of iridium, while the demand for this metal is rapidly increasing.

JAMES WATT MEMORIAL.—A memorial statue is about to be erected in Greenock, Scotland, on the site of the humble cottage in which James Watt was born. For this purpose subscriptions of small amounts—five dollars or less—are being solicited in various countries. Mr. Andrew Carnegie is chairman and Mr. Theodore Dwight, 99 John Street, New York, is secretary and treasurer of the American committee.

CASE SCHOOL OF APPLIED SCIENCE.—The inauguration of Mr. Charles Sumner Howe as president of the Case School of Applied Science in Cleveland will take place on May 11. The inauguration exercises will be held in the Euclid Avenue Congregational Church. Before the inaugural address of President Charles S. Howe, the following gentlemen will deliver addresses: Dr. Worcester R. Warner, representing the board of trustees; President James B. Anzell, President Henry S. Pritchett, Mr. John R. Freeman and President Charles F. Thwing. An inauguration banquet will be held in the evening at the Hollenden.

THE USE OF COPPER SULPHATE IN ALGERIA.—From a recent consular report we gather that sulphate of copper is extensively used in Algeria in viniculture. All of it is imported, the custom house statistics showing a total of nearly 2500 tons for the year 1902, although the yearly average is somewhat larger. The Algerian custom house statistics credit the United States with about 120 tons, although it is probable that the actual amount is much larger, owing to the goods coming through

French entrepôts. The general opinion among purchasers in Algeria is that a much greater quantity could be exported to that country from the United States, provided it were sent by direct shipment in sufficient quantities to reduce freight. There is a demand for it in Algeria, and the American Consul suggests that exporters correspond with M. Buisson, secrétaire de la présidence du Tribunal de Commerce, Algiers, and also with the presidents of the chambers of commerce of Oran, Constantine, Phillippeville, and Bone. All communications should be written in French and prices quoted in French currency and metric weights.

FIRE PROOF WIRE

By WILLIAM H. EASTON, PH. D.

Without question one of the most vital problems of to-day is to make the materials with which we come into constant contact resistant to the action of fire. Probably never before in the space of two months have greater calamities from fire occurred than we have witnessed this year, proving equally the failure of our present methods of fireproofing and the need for more effective ones. There is no question that electricity should come in for its share of consideration and improvement, and that electrical machines and electrical conductors should be as entirely without the power of burning as a steam pipe. It is indeed a curious example of the unfitness of things when we find electrical conductors covered with such inflammable materials as cotton, silk, rubber, paraffin, etc.

The only successful covering for wires to be used in coils for machines, etc., is a double map of cotton, and this is rendered dry and fireable at a temperature slightly above the boiling point of water, and it needs but a slight sparking, a trifling overload, or one of many accidents so familiar to electrical men to cause this to char, become conducting, form a short circuit, and set the whole apparatus in a blaze. When rewinding, costly and time-consuming, must take place, and the knowledge remains that the same may occur at any moment. This has reacted powerfully upon electrical machinery in general, and is one of the greatest stumbling-blocks in the way of electrical progress. What is true of dynamos and motors is true of all electrical devices employing coils or windings of any description, and the care of that delicate material weighs the most heavily upon the electrical man's shoulders.

There is another and possibly a more important consideration. Every house, every building, every factory that employs electricity is penetrated in every direction with heavy wires to carry the current. Examine a piece of this wire, with its several cotton braids and waterproofing of rubber or paraffin composition, and then touch a lighted match to it, and watch the flame creep along and the burning drops fall. How safe would one feel should a break or piece of careless wiring or a slight irregularity in the circuit cause such a blaze to spread in every direction in contact with woodwork and wall paper. Defective insulation is responsible for great losses of life and property, but we continue to polish the stove with coal oil and trust to luck.

While all other conditions for insulation have been successfully fulfilled, the force of heat has as yet remained unmanageable. A temperature of 150° C. is sufficient, if maintained, to render useless every insulation at present used upon wires, and it is especially necessary to overcome this difficulty.

These are some of the considerations that have called the Heany Fire Proof Wire into existence, and to fill the gap still left open, an entirely new departure in insulation has been taken. The wire is insulated by first covering it with a fine even web of asbestos, which is then passed through a paste of cement that upon heat and pressure forms a uniform, homogeneous mass, uniting wire and fibre, together chemically, and forming a smooth white, almost porcelain-like covering. This

insulation is very strong and flexible, so that it will resist abrasion and will not peel, crack or twist off. Weathering does not affect it, and short of being directly immersed in water it is moisture proof. It can be made of any desirable thickness from but slightly heavier than writing paper up to cable sizes. Its most important feature is its resistance to heat, in which respect it is practically indestructible for being composed entirely of mineral matter, it cannot burn, and will withstand temperatures that will cause the copper within to melt without breaking down. A coil in Mr. Heany's laboratory at York, Pa., has been heated to bright redness many times by a powerful alternating current and still remains as good as ever. This demonstrates that no accidental overload can injure the machine and makes the fusing point of the metal and the safety of the building the considerations in determining the factor of safety. This also allows much smaller wire to be used in machines, thus reducing the first cost and the size, and producing a reliable machine instead of a rather dubious and delicate piece of mechanism.

For line wire, this insulation is covered with a protecting braid and the whole treated with a water-proofing composition that is entirely fireproof also, so that the danger from burning wires is entirely obviated. It is not so much the heating of the wire, nor the sparks or arc formed by a break or short-circuit that cause fires to start, but it is the subsequent blazing of the insulation that has been so destructive, and this cannot take place with the Heany wire.

WATER-WHEEL GOVERNORS.

On account of the importance of cheap power for electrochemical industries, and for the further reason that we have in the United States a number of large water powers just where they are wanted—i. e., not on remote, out-of-the-way spots, but at places suitably located for shipment of the goods—there has been, as is well known, an intimate connection between the evolution of certain large electrochemical industries and the development of water powers in this country. Niagara Falls is the example par excellence, illustrating this development. However, there are also smaller hydroelectric plants in connection with metallurgical works in mountain districts. This development may be safely expected to go on with greater energy in future, since the advantages of the use of electric power and lighting for mining and metallurgical plants is now well understood; this will at the same time encourage the introduction of electrochemical methods in metallurgical works.

Under these circumstances the principal requirements of hydraulic plants are of great interest to electrochemists and metallurgists. It is a fact that the electrochemical or electro-metallurgical engineer in his work is often confronted with troubles resulting from an insufficient regulation of the power supply. In water power plants a detail, though small, yet of great importance, is the water-wheel governor. For this reason the following notes on the water-wheel governors, made by the Lombard Governor Co., of Boston, Mass., should be of great interest to our readers.

All of the governors made by this company consist primarily of a hydraulic piston which applies its thrust in either direction to the water-wheel gates in the act of opening or closing them. The piston rod terminates in a rack which is geared positively to the gate shaft. One complete stroke of the governor piston entirely opens or closes the water-wheel gates; consequently, any motion of the governor piston, less than a complete stroke, causes a correspondingly smaller motion of the gates. For example, if the governor piston moves one-half its complete travel, it will one-half open or close the water-wheel gates. If the governor piston moves one-tenth its full stroke, it opens or closes the gates one-tenth.

The above action may be seen in a general way from Fig. 1, which illustrates the type F governor of the Lombard Co.

This governor, which is the simplest in construction, and smallest in size made by them, is adapted to regulating Pelton and all forms of impulse or tangential water-wheels. It will be seen that its piston terminates in a rack which rotates a gear. The central shaft of this gear sector is coupled directly (or, if that is not possible, is geared) to the rock shaft controlling the deflecting nozzle; or, if this governor is used to regulate a small turbine, the central shaft of the gear sector is coupled directly, or through gearing, to the gate stem. Thus, it will be seen that, as the piston travels in or out, the nozzle will deflect the water off from or on to the water-wheel or open or close the gates of the turbine, as the case may be.

If, for example, the piston is capable of moving through its entire stroke in two seconds, it follows that the water-wheel gates will be opened or closed in two seconds; and any correspondingly smaller gate movement will be made in a correspondingly smaller space of time. It is theoretically true, and it has also been amply demonstrated in practice, that the quicker the water-wheel gate is moved to the correct position after a load change occurs, the smaller will be the speed variation. The Lombard Governor Co. builds governors of a number of sizes, and in practice selects one with a piston of such a size that it is capable of moving the gates through their

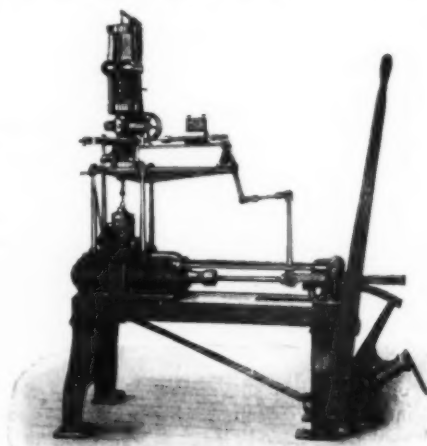


FIG. 1.—WATERWHEEL GOVERNOR.

entire range in two or three seconds. If it is found for any reason—as, for example, weakness of the flume or wheel case—that the gates cannot be safely handled so quickly, then the governor may be adjusted to move as slowly as required.

In the governor shown in Fig. 1 the hydraulic piston is moved by water under flume pressure. There is a pipe-threaded orifice under the bed of this governor, and this is connected directly to the flume. Therefore, this type of governor is adapted to high head-plants in general, or to such low-head plants in which a small amount of water is available under high pressure. Where the water wheels operate under low head, or where there is no water available under high pressure, a type of governor is used in which the piston is moved by oil under pressure. Fig. 2 shows Type A governor. This governor operates with oil under pressure as above referred to.

It will be observed that under the bed of the governor is a cylindrical tank. This is divided into two parts by a tight partition, the location of which may be seen from the row of rivet heads. The larger part of the tank (to the left in Fig. 2) is about half full of oil. The upper half of this pressure tank contains air under about 200 pounds pressure to the square inch. The smaller end of the tank (to the right in Fig. 2) contains a vacuum. The pressure and vacuum are constantly maintained by a pump located on the farther side

of the head of the governor, and driven by the larger pulley shown, which is belted so as to slowly rotate all the time the governor is in operation.

When the governor piston moves the water-wheel gates, it is because oil from the pressure tank is let in on one side of the piston; simultaneously the oil on the other side of the piston is vented into the vacuum tank from whence it is immediately pumped into the pressure tank.

Fig. 3 shows the top of one of the governors of the Lombard Co.;

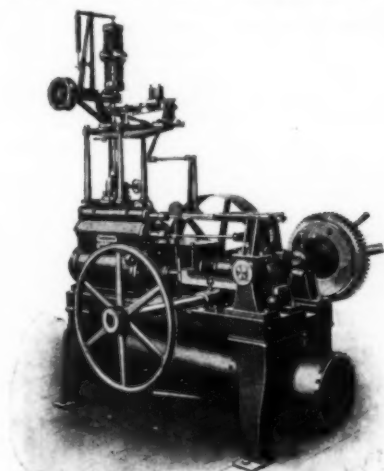


FIG. 2.—WATERWHEEL GOVERNOR.

ard Co.; it is through this mechanism that the governor is made to open or close the water-wheel gates when the load varies and the speed tends to change. All governors of the company are fitted with practically the same top, the action of which may be briefly described as follows.

The pulley shown in Fig. 3 is belted directly to the water-wheel shaft and drives the governor balls which, when rotating at normal speed, stand out considerably from the axis of rotation. The mechanism is such that as the balls spread out, under the action of centrifugal force they depress the top plate into which the flat springs supporting them are inserted. This top plate is attached to a rod which passes down through the hollow vertical shaft, carrying the balls, and terminates in a small vertical piston valve located behind the hand-wheel shown near the bottom of the cut.

It will be seen therefore, that, as the balls fly out under the influence of increased speed, they will depress the piston valve and, conversely, as they travel inward when the speed becomes below normal, they will lift it. The valve stem or rod above referred to is of such length that when the balls are in the position due to normal speed, the valve is closed; but the moment when the speed becomes above or below normal, the piston valve admits oil or water, as the case may be, to one side or the other of the main piston of the governor. This causes it to open the water-wheel gates if the speed is below normal, or close them if the speed is above normal.

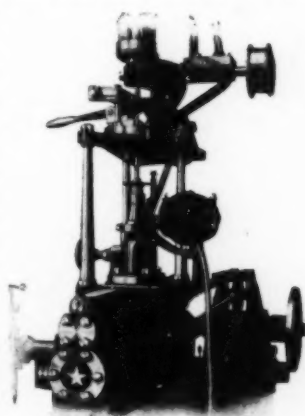


FIG. 3.—WATERWHEEL GOVERNOR.

As the rotating balls are exceedingly sensitive, and as the piston valve has an extremely small lap, the least change in speed of the water-wheel causes the governor to open or close the water-wheel gates.

It should be remembered that not only do the governor balls possess the property of inertia, and fail to instantly respond to changes in speed, but also that the water, as it approaches the water-wheel possesses the same property in a marked degree, and hence the water-wheels do not respond instantly to changes of load, so that the governor balls do not feel the changes in load instantly. It is therefore evident that the governor top must be of such design that it will move the gates to the correct position for any change in load irrespective of the momentary speed of the water-wheel. For example, if one-half the load on the water-wheel were instantly thrown on or off it does not follow that its gates should at once be moved to a position corresponding to one-half more or one-half less load. The governor should as quickly as possible move the gates to such a position that the water, at the velocity which it has at that instant of time, will turn the water-wheel at its normal speed and then as the water gradually assumes the new velocity called for by the new load, move the water-wheel gates to their normal position for normal speed at normal water velocity. It would not be appropriate in this article to enter into a complete description of how this is accomplished. The makers, however, emphasize the fact that in their governor tops all possible adjustments are made to overcome the tendency of the water-wheel to race. Speed recorder strips, obtained in practice, prove that they have been successful in this all important matter.

Governors made by the Lombard Governor Co. are built in twelve standard types adapted to various conditions; they also build special governors for exceptionally large units, and at present are constructing a special governor to develop 100,000 foot pounds in two seconds, to regulate the largest water-wheel now in existence.

Their electric speed controller which may be attached to all types of governors made by them, permits of starting and stopping the water-wheels from a distant point, as, for example, from the switchboard. This device also makes it possible to adjust the speed of the water-wheels with the utmost accuracy, and is of especial advantage in paralleling alternators. All told, their governors are used to regulate about half a million horse power of water-wheels in this country, in addition to a large number of installations abroad. Their shops, which are located in Boston, are equipped throughout with the most modern machinery, and all governors are built with interchangeable parts.

FILTER PRESSES.

We herewith illustrate one of six filter presses supplied by the Niles Tool Works, Hamilton, Ohio, to a gold mine in the State Chihuahua, Mexico, for the cyanide treatment of slimes. It possesses some interesting features made necessary by the location of the mine, to which the machines had to be brought by mules. No piece, therefore, exceeds the limit of weight admissible for this method of transportation (300 to 325 pounds). The fixed head, accordingly, had to be built in cast-iron sections, while the sliding head is made up from steel plate. The side bars are made of a deep section of channel bar, and the filtrate trough is of sheet steel for lightness. The filter presses are provided with a double washing arrangement, giving the concentrated washings so desirable in cyanide extraction, and the whole plant has been in satisfactory operation for some time.

In this connection some general notes on the construction and uses of filter presses may be of interest. One of the most frequent and most important operations in all chemical industries is the separation of liquids from solid matters suspended in them, whether the object be to recover the pure liquid or

the solid matter, or both. Filter presses have found an extended application in various chemical industries for this purpose, their advantages being easily explained by their construction.

A filter press consists in principle of a number of chambers bounded by filtering material, most of cotton cloth. These chambers may be formed in two ways. Either plates are used with recessed faces, the recesses in adjoining plates together forming the chamber, or flat plates are used, alternating with frames of the desired depth. In either case the plates are provided with vertical grooves or both vertical and horizontal grooves, both sides being covered with filter cloths. The plates and frames are clamped together between two heads of a strong screw lying in the axis of the press. The two types are commonly distinguished as the chamber press, and as the frame press.

All the plates, and one head, are provided with a hole in the center, and similar holes are made in the filter cloths, a joint being made between the cloths and the plate by suitable unions. A continuous feed channel through the whole press is thus formed and the liquid to be filtered enters through this channel under pressure, fills all the chambers, and is then forced to pass through the filter cloths, leaving suspended solid matter behind, which gradually fills the chamber. The clear liquor passes down the corrugations on the faces of the plates, and finds its way through a channel, which connects the vertical

termines the thickness of the cake. This size depends entirely on the material, and is a matter for experiment. As long as a cake still allows liquid to pass through it without excessive pressure, so long filtration will continue. Some materials will form cakes up to 3 and $3\frac{1}{2}$ inches thick, but for general purposes, the depth of the chamber may be chosen as $1\frac{1}{2}$ inches in most cases.

After filtration, another operation may be performed to which the filterpress lends itself readily, namely, that of washing out the cakes with water or some other solvent, so as to remove the last traces of the mother liquor from them. For this purpose a channel is provided similar to the feed channel, but with ports into alternate chambers only, leading into the corrugated surface behind the filtercloths. Water or any solvent is admitted and the outlets on the plates having inlet ports for the above, are closed. The washing water is thus forced to fill all the grooves, to pass through the entire thickness of the cake, through the opposite filter cloths and out through the outlet passages in alternate plates. Air outlets are provided at the top of the chambers, so as to allow the water to reach the entire surface of the cake. Washing is finished when no more soluble matter passes away with the wash water; this is easily controlled by means of a hydrometer in the delivery pipe. When necessary, the cakes after washing may be dried by passing through them compressed air or superheated steam, in the same way as the wash water.

The material of which the press is made depends somewhat on the purpose for which it is to be used. Unless the nature of the liquid under treatment permits it, cast iron is employed for the plates; otherwise tinned or galvanized cast-iron plates are used or gun-metal or phosphor bronze, if necessary. In some cases it is necessary to use wooden plates, made of pine or oak, for instance, in aniline or alizarine dye works.

For every purpose it is necessary to use the proper filter cloth. To get the best cloth is a matter of experiment. The cloth must be of sufficiently close texture to retain all the solid particles, yet not closer than



FILTER PRESS.

grooves and leads into an outlet port. Filtration continues, with a gradually rising pressure, until the whole chamber is filled with a solid cake. The feed is then cut off, the press is unscrewed, and the plates are separated. The cakes of solid matter drop out, the press is screwed up and is then ready for another operation.

The efficiency of the filter press is due to the very large filter area in a comparatively small space and to the use of high pressures which permit rapid filtration.

Of the two types of filter presses, the chamber press is the cheaper one, since it has only half the number of joint faces as the frame press. The chamber press has the further advantage that as soon as the press is opened and the plates separate, the cake drops out. The feed channel being large and central, there is very little risk of its being clogged, even with heavy materials.

In the frame press the feed channel is generally placed in flaps outside the joint of the plates and frames, so that a larger filtering surface is obtained and the cloth unions are avoided. On the other hand, the ports leading from the passage into the chamber, are more easily clogged by heavy material than the central channel of the chamber press. When the frame press is opened, the cake remains in the frame and this type is, therefore, obviously unsuited when the material does not form a solid cake.

To get the best results in any particular case, it is necessary to choose the proper depth of chamber, which, of course, de-

termines the thickness of the cake. This size depends entirely on the material, and is a matter for experiment. As long as a cake still allows liquid to pass through it without excessive pressure, so long filtration will continue. Some materials will form cakes up to 3 and $3\frac{1}{2}$ inches thick, but for general purposes, the depth of the chamber may be chosen as $1\frac{1}{2}$ inches in most cases.

The feeding of the filterpress is also a matter deserving close attention. As soon as the turbid liquor is admitted a film of solid matter is deposited on the surface of the cloth, and this film then really acts as the filter, while the cloth serves as support for the film. It is essential that this solid matter should not be driven in the pores of the filter cloth, and the pressure must, therefore, be put on, increased gradually and violent fluctuations avoided. Presses may be fed by suitable pumps or by means of compressed air. The Niles Tool Works have paid special attention to the latter method, which avoids all the trouble caused by the valves and plungers of pumps pumping thick liquid, and provides at the same time a ready means for drying the cakes.

LIBRARY OF UNION ENGINEERING BUILDING.—The libraries of the Institutes of Electrical Engineers and Mining Engineers, and of the Society of Mechanical Engineers, which will be assembled in the Union Engineering Building, will commence with about 50,000 volumes, many of them of inestimable price.

INDUSTRIAL NOTES

We have received from Messrs. FOOTE, PIERSON & Co., New York City, their catalogue 11 of electrical measuring and scientific apparatus, which contains illustrated descriptions of their condensers, galvanometers, bridges, resistance boxes, standard resistances, compensation apparatus, standard cells, cable-testing sets, X-ray tubes, photometers, voltmeters and ammeters.

"APPERT" GLASS.—The Scientific Materials Co., of Pittsburgh, Pa., has recently issued an illustrated pamphlet on "Appert" glass, which, by reason of its composition and method of manufacture, can be made into vessels of any symmetrical shape possessing unusual strength and resisting perfectly the action of acids, electricity and climatic changes. Such Appert glass vessels are rapidly supplanting containers heretofore made of clay, wood, metal, etc. They are practically indestructible, are easily cleaned, and the contents are always in full view.

THE POWER AND MINING MACHINERY Co., of New York City, have received orders from the Amparo Mining Co., of Philadelphia, for one 190-hp., and two 130-hp. Crossley gas engines, and six Loomis generators, with two 10,000 cubic foot holders, also mining machinery, consisting of crushers, Bruckner roasting furnaces, condensing chambers, etc. The same company has received an order from the Nogales Copper Co., of Chicago, for installation in Mexico, for three 330-hp. Crossley gas engines, from Loomis-Pettibone gas generators, one 10,000 cubic foot holder and one 5000 cubic foot holder. This contract also includes the mining machinery for the plant.

We have received from the CROCKER WHEELER Co., of Ampere, N. J., bulletin 40 on crane motors and flyers; 144 (rehabilitation of a flooded power plant at Kansas City), 145 (electric drive for machine tools, with methods of variable speed control), and 153 to 168 (various examples of machine tool equipments, such as motor drive for band saw, band saw setting and filing machine, 3-inch, bolt cutter, 30-inch drill press, four-spindle mud-ring drill, 24-inch lathe, gap lathe, with 28 and 48-inch swing, heavy turret lathe, light and heavy milling machine, gear shaper, horizontal boring machine, 51-inch boring and turning mill, punch, rotary bevel shear, plate-bending rolls).

THE LABORATORY AND SCHOOL SUPPLY Co., who have recently opened a New York office at 20 to 24 East Twentieth Street (as a branch of the Vereinigte Fabriken für Laboratoriumsbedarf, a consolidation of the firms of Dr. Peters & Rost and Max Kaehler & Martini of Berlin, Germany), have sent us their very complete and fully illustrated catalogues of chemical apparatus and instruments, and their special list of electrochemical apparatus. The latter deals with apparatus for generating current (galvanic cells, storage batteries, thermo couples, dynamos), conductors and accessories (switches, rheostats, etc.), measuring apparatus for laboratory work and special apparatus for electrochemical work, such as electrolytic cells, electric furnaces, induction apparatus and apparatus for electroanalysis.

DATA ON INSULATING MATERIALS.—Under this title the Dielectric Manufacturing Co., of St. Louis, Mo., has issued a neat pamphlet containing diagrams with the following important curves: Break-down potentials in air as function of length of air-gap, dielectric strength of solid and pasted mica curves showing the importance of the time element in applying potential to breakdown insulating materials, curves showing the importance of drying and varnishing sheet insulating materials, curves showing the dielectric strength of different sheet insulating materials compared with oil and mica, a curve showing the great decrease in insulating qualities of transformer oil by presence of small amounts of water, and curves showing permanent insulating qualities of "dielectrol" (an

insulating compound made by this company) when in continued contact with copper on the inside of coils.

INSULATING COVERING FOR CABLES TO PREVENT FIRES.—The dangers from cable fires are well known. When the wires in a cable are overheated, the insulating compound frequently melts and brings two adjacent uncoated wires together. This creates a short-circuit, with the consequent burning and fusing of the wires. This sets fire to the insulation, as well as to the outer coating or wrapping, which is usually of cotton braid. The fire is thus communicated to the next cable, and so on. To prevent such accidents which may cause enormous damage, the H. W. JOHNS-MANVILLE Co., of New York, have devised an insulating covering for the cables, which so fire-proofs these cables so as to prevent, in case of short-circuiting of one, the ignition of the others. It was first used by the Niagara Falls Power Co., hence its name, "Niagrite." Niagrite is bound spirally about the cable to be protected. The composition will dry out under ordinary conditions in about twenty-four hours and become very hard and absolutely fire-proof.

ALUMINOTHERMICS IN THE UNITED STATES.—In a test of thermit, made by the Pennsylvania Railroad Co. in Altoona, the riser from the weld of the steel frame was drawn out under the hammer into a bar some 3 feet long and turned down and broken. The analysis of the metal is as follows:

Carbon	0.102 per cent
Manganese	2.330 "
Phosphorus	0.070 "
Silicon	1.227 "
Sulphur	0.034 "

The following was the result of the physical test:

Tensile strength in pounds per square inch, 91,600.
Elongation in 8 inches, 21.5 per cent.
Appearance of fracture, silky.

An engine, the frame of which was repaired with thermit about the 20th of February, has been on the road ever since. The thermit used for this weld had in it a mixture of 2 per cent pure manganese, free from carbon, and 5 per cent iron punchings.

PIPE COVERING TESTS.—In a recent bulletin of the H. W. Johns-Manville Co., of New York City the results of pipe covering tests are given which were made in England, and in which the asbesto-sponge felted section covering of the H. W. Johns-Manville Co. was compared with some other coverings. F. M. Long, city electrical engineer of Norwich, found that the amount (in pounds) of steam condensed per hour in 12 feet of 3-inch wrought iron pipe (3.55 inch external diameter) with different coverings was as follows:

Asbesto-Sponge Felted Section Covering, 1 inch thick	1.82 lb.
Magnesia Sectional Covering.....	2.38 "
Asbestos Composition	2.51 "
Mica Composition, put on 1½ inch thick, but reduced in dry to 1¼ inch thick.....	3.17 "

The steam pressure was 180 pounds, and the temperature of the room from 70° to 79° Fahrenheit. A radiation test was made by Frank Ayton, chief engineer of the Ipswich Corporation Electric Department, the steam pressure being 156 pounds. With asbesto-sponge felted section covering, of 1¼-in. thickness, the surface temperature was 149° F., with mica composition of 1¼-inch thickness, 179° F.

DIGEST OF U. S. PATENTS

PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend,
Patent Lawyers,

National Union Building, Washington, D. C.

THE PRODUCTION OF ALUMINIUM FROM MOLTEN ELECTROLYTES.

244,234. July 12, 1881. Paget Higgs, New York, N. Y.

Melts ores of aluminium, copper, magnesium, chromium,

platinum, iron, etc., with borax, boracic acid or silica, to form a borate or silicate, and electrolyzes. For example, melts cryolite and borax in a clay crucible at a temperature of 1000° C., lowers to 900° C., and electrolyzes. The aluminium is deposited in globules which are united by again raising the temperature to 1000° C. Mentions the electrolysis of copper borate, iron silicate and iron slag.

315,266. April 7, 1885. Moses G. Farmer, New York, N. Y.

Electrolyzes molten chlorides or fluorides of aluminium, or double haloids of aluminium and ammonium or sodium. Cathode vessels of aluminium or platinum; anodes of carbon or aluminium. May employ a group of three depending anode rods with means for rotating them to stir the bath. A number of cells are connected in series, each vessel having an integral extension which is secured to the anode of the next cell.

362,441. May 3, 1887. Richard Gratzel, Bremen, Germany.

Reduces aluminium from its single or double fluoride, *e. g.*, cryolite, by magnesium, calcium, barium or strontium. May fuse the fluoride and stir in solid or molten magnesium, or lead in magnesium vapor by a tube; or magnesium may be liberated in the bath by electrolyzing the fluoride mixed with (1) magnesium chloride in the proportion of three equivalents to one of fluoride; (2) potassium magnesium chloride or sodium magnesium chloride, as carnallite; or (3) calcium, barium or strontium chloride. May introduce copper or use a copper cathode to produce an aluminium copper alloy.

387,876. August 14, 1888. Paul Héroult, Laufen-Uhwiesen, Switzerland.

Electrolyzes molten alumina, without flux, using a molten cathode of copper or iron. May thus produce aluminium bronze, ferro-aluminium, aluminium-steel, aluminium-brass, etc. Cathode vessel of carbon, surrounded by powdered carbon and inclosed in masonry. Anode of carbon. E. m. f., 20 to 25 volts.

400,664. April 2, 1889. Charles M. Hall, Oberlin, Ohio.

Electrolyzes alumina dissolved in molten potassium aluminium fluoride, K_2AlF_6 . May add or substitute for part of the potassium fluoride, lithium fluoride. For example, may use $KLiAlF_6$ or $K_2Li_2AlF_6$, conveniently produced by neutralizing aluminium hydrate and potassium or lithium carbonate with hydrofluoric acid. These baths are of less specific gravity than aluminium, which sinks to the bottom. Cathode vessel, steel or copper lined with carbon. Anode, platinum, or copper which becomes coated with a protecting layer of oxide. E. m. f., 3 to 4 volts.

400,665. April 2, 1889. Charles M. Hall, Oberlin, Ohio.

Electrolyzes alumina or bauxite dissolved in molten calcium aluminium fluoride, $CaAl_2F_6$, or $Ca_2Al_2F_{12}$; or may employ the corresponding salts of barium or strontium. The deposited aluminium rises to the top of the bath, but may be alloyed with iron or copper at the cathode to produce an alloy which is heavier than the bath. Or potassium aluminium fluoride, K_2AlF_6 , may be added to about two-thirds the weight of the original bath, to give a bath lighter than aluminium. For the production of pure aluminium, uses carbon electrodes and a covered vessel with a lining of carbon. A carbon partition may depend between the electrodes. A floating layer of alumina is employed on the cathode side of the bath to exclude air.

400,666. April 2, 1889. Charles M. Hall, Oberlin, Ohio.

Electrolyzes alumina or bauxite dissolved in a molten mixture of sodium aluminium fluoride, Na_2AlF_6 , and calcium aluminium fluoride, $CaAl_2F_6$, produced by melting together calcium fluoride, 224 parts, cryolite, 421 parts, and aluminium fluoride, 845 parts. Three to 4 per cent of calcium chloride is added to prevent the bath from thickening in use. Aluminium sinks in this bath. E. m. f., 6 volts.

400,667. April 2, 1889. Charles M. Hall, Oberlin, Ohio.

Electrolyzes alumina dissolved to saturation in a molten

bath of calcium fluoride, 234 parts, cryolite, 421 parts, and aluminium fluoride, 845 parts, plus 3 to 4 per cent of calcium chloride. For the production of pure aluminium, uses a carbon cathode; for alloys, one of iron, copper, etc. E. m. f., 4 to 8 volts. Dips out the aluminium by a ladle covered with carbon. Increased resistance in the bath and a high percentage of carbon monoxide relative to carbon dioxide evolved at the anode, indicates too low a percentage of calcium chloride.

400,766. April 2, 1889. Charles M. Hall, Oberlin, Ohio.

Electrolyzes a solution of alumina in sodium aluminium fluoride, Na_2AlF_6 , produced by melting cryolite, 421 parts, and aluminium fluoride, 338 parts. May use a solution of alumina in potassium aluminium fluoride, K_2AlF_6 . Anode, platinum, carbon, or copper which becomes coated with a layer of oxide. To render the bath more fusible, an equivalent of lithium fluoride may be substituted for one-fourth of the sodium fluoride.

464,933. December 8, 1891. Charles S. Bradley, Yonkers, New York.

Melts and electrolyzes ores, *e. g.*, cryolite, by the same electric current. The molten bath may be held in a cavity in a mass of the ore, or on a bed of carbon and surrounded by a wall of the ore, in which case the carbon bed may serve as an electrode. The ore may be held in a brick receptacle or placed on a brick hearth.

466,460. January 5, 1892. Thomas A. Edison, Menlo Park, New Jersey.

Electrolyzes molten volatile substances, *e. g.*, aluminium chloride, by maintaining them under pressure, which may be produced by confining the evolved chlorine or other gas. Vessel, iron or nickel, which may be lined with fire-clay. Cover, several layers of mica, bolted onto the vessel and supporting the electrode.

468,148. February 2, 1892. Charles S. Bradley, New York, N. Y.

Same as 464,933, except claims.

473,118. April 19, 1892. Paul Héroult, Laufen, Switzerland.

Electrolyzes molten alumina or clay. E. m. f., 12 to 15 volts. May use a molten copper cathode, producing a silicon-aluminium-copper alloy. Alumina and copper fed in during the operation. Anode, a bundle of carbon plates, interleaved with metal and bound by clamps; automatic feed, controlled by an ammeter. Cathode vessel, carbon with an iron shell cast around it. Brass or copper terminal studs pass through the shell into the carbon. The vessel has a tap-hole with a spring-pressed carbon stopper, and is covered with a graphite plate or bricks, having covered feed openings. A filling of graphite powder is interposed between the edges of the cover and the iron casing.

473,866. April 26, 1892. Charles S. Bradley, Yonkers, New York.

Electrolyzes ores, *e. g.*, cryolite, by placing carbon electrodes horizontally in a heap of the ore, and directing a blow-pipe flame upon the apex or top of the heap until a pool of molten ore collects around the ends of the electrodes. The ore may be contained in a receptacle, or simply piled in a heap upon a brick hearth.

476,256. June 7, 1892. Michael Emme, Atlanta, Ga.

Electrolyzes alumina, previously calcined and dissolved while hot, in a molten mixture of aluminium fluoride, 10 parts, and aluminium chloride, 1 part. Cathode vessel, cast-iron with a lining of retort-carbon insulated from the iron by a paste of asbestos and bauxite. The vessel has a tap-hole containing a carbon cock. Anode, a group of ten or fifteen depending carbon rods, hung in concentric circles by terminals clamped in lateral recesses in the radial bent arms of a vertically-adjustable copper spider.

